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CRITICS AND DISCUSSIONS

To Evaluation of New Methodical Approaches in the Sequence Stratigraphy Analysis

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Abstract—Despite great practical achievements, sequence stratigraphy failed to elaborate until now the reliable technique for establishing relative sea-level fluctuations (RSLF). The method proposed recently by Yu.A. Volozh with colleagues for determining the RSLF represents one of interesting but unconvincing attempts in this respect. Use of their method for fundamental and practical purposes requires prudence because of potential errors.

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Volozh et al. (2004) published an article dedicated to sequence stratigraphy and technique of determining the relative and absolute sea-level changes. This remark is our reaction to that paper. Prior to going to the essence, we should note that only one of us is persistently dealing with sequence stratigraphy and relevant methods. Two others are stratigraphers utilizing in practice data obtained by sequence stratigraphy together with other materials, i.e., they are users of the data. Nevertheless, they are able to assess from the standpoint of general geology the results obtained by sequence stratigraphy, relevant sections, and paleogeographic reconstructions for particular time levels in some regions. In this context, contribution of authors into this discussion is not equivalent: the principal ideology belongs to A.E. Shlezinger.

Sequence stratigraphy originated as a branch of geology in the mid-1980s in the course of seismostratigraphic studies. Its theoretical and methodological basics are formulated by P.R. Vail and colleagues (Vail, 1987; Vail et al., 1991). Nevertheless, that branch is not only a part of seismostratigraphy and represents an autonomous scientific and applied discipline. A sequence or three-dimensional sedimentary body formed under relative sea-level fluctuations is principal unit in sequence stratigraphy. The sequences consist usually of three successive units or tracts corresponding to low transgressive, and high sea level stands.

Sedimentary complexes corresponding to Vail's sequences can be the marker units for global correlation of sedimentary basins. In fact, the suggested autonomous stratigraphic method can be used for correcting and specifying age estimates obtained by other means of stratigraphic subdivision. Nevertheless, sequence stratigraphy collides with serious difficulties. First, discrimination of the real eustatic component from relative sea-level fluctuations (RSLF) requires statistical analysis of tremendous database that is insufficient so far. Second, the RSLF recognition based on coastal onlap, the only reliable parameter recommended by Vail, is difficult in fact, because relevant events are recorded only in sedimentary basins of tectonically passive zones. Third, the technique applied for discrimination of eustatic sea-level fluctuations from regional ones in sedimentary sections remains poorly developed so far. The scientific aspect of sequence stratigraphy needs further elaboration therefore. Its applied aspect developed more successfully, because main hydrocarbon reservoirs are concentrated in deposits of the low sea-level stand that is important for petroleum exploration (Shlezinger, 1998; Fedotov and Shlezinger, 1999; Kovylin et al., 1999; Gladenkov and Shlezinger, 2001).

An example of recent attempts to elaborate new approaches to the sequence stratigraphy analysis is work by Volozh et al. (2004) who argued that technique of constructing sea-level fluctuation curves is admissible for areas, where sedimentary sections recorded coastal onlap, but this is however, an extremely rare case, as it follows from analyses of numerous data. In more frequent cases, the accumulative advancing of paleoshelf edge toward basin shore (vertical and lateral transgression of strata boundaries) can be reconstructed based on sedimentary clinoforms. Clinoforms are particularly frequent in sections of the West Siberian basins in the stratigraphic interval from the basal Upper Jurassic to the Aptian of the Lower Cretaceous inclusive. Volozh et al. (2004) attempted to interrelate the RSLF with vertical and lateral offsets of paleoshelf edge. According to their interpretation of sequence stratigraphy data on the Late Jurassic (159 Ma) to Barremian (125 Ma) sediments, sea level rose by 1000 m in the Middle Ob–Nadym–Pur and by 400 m in the Near-Ural subbasins. Unfortunately, no evidence was

presented for correlation between the RSLF and offsets of accumulative paleoshelf edge. Moreover, they emphasized that it is impossible to establish such a correlation, since coastal onlap is not observable in the studied areas. As is known, the seaward advancing of a basin shore reflects the relative fall of sea level, while the paleoshelf edge migrated in the same direction during the sea-level rise (Volozh et al., 2004).

At the same time, it was previously established based on seismostratigraphic data, in particular, on clinoforms of the initial early Neocomian basin, that its depth increased from 150–200 m in the east to 500–600 m in the west (*The Bazhenovo Horizon…*, 1986; *Paleolandscapes of the Western…*, 1968). This was explained by additional local isostatic subsidence under weight of clinoforms and their compaction that led to deepening of the paleobasin (Igoshkin and Shlezinger, 1990a, 1990b; Shlezinger, 1998). The subsidence created successive transition of shelf layers to clinoform bodies, boundary between which is getting younger and rising in the western direction. These observations show that migrating edges of accumulative shelves cannot be used to define the RSLF, providing only an opportunity to judge about the paleobasin depths.

Other data also point to doubtful character of interpretations by Volozh et al. (2004). The relative sea-level rise by 1000 m in the Neocomian, which is declared in their paper, would result in a greatest transgression and flooding of the entire Siberian platform, but this is inconsistent with geological data. For example, remains of benthic organisms, ichnofossils, invertebrate taphonomy, lithology, geochemistry, and parametric calculations (*Paleolandscapes of the Western…*, 1968; *Atlas and Explanatory…*, 1976; Bochkarev and Fedorov, 1985; *The Bazhenovo Horizon…*, 1986; Gurari et al., 1988; Zakharov et al., 1998; Shurygin et al., 1999) indicate that sea basins of the Volgian and Berriasian time were relatively deep and spacious. In the Valanginian and Hauterivian ages, the sea became substantially shallower and reduced in area according to paleontological and sedimentological data (*Paleolandscapes of the Western…*, 1968; *Atlas and Explanatory…*, 1976; Sahagian et al., 1996). Geocratic regime was characteristic of the Barremian and Aptian, when lacustrine–fluvial sedimentation and associated coal accumulation were in progress within most areas of West and Northeast Siberia (*Atlas and Explanatory…,* 1976).The assumed high sea-level stand in West Siberia during the Barremian (Volozh et al., 2004) is inconsistent therefore with factual data as well, since Barremian sediments are of continental origin almost everywhere (Parker, 1967). In the Aptian only, sea environments were preserved in the near-Atlantic part of the Arctic region (Svalbard).

Discrimination of sequences (Volozh and his colleagues propose to term "vailites") and their classification into units corresponding to low, transgressive, and high sea-level stands is done in the work under consideration only for clinoform bodies and without explanations. Only thinner parts of clinoform sections are attributed to sediments of the low sea-level stand. At the same time, in West Siberia there are distinguished transgressive (clinosheets) and regressive (clinocycles) clinoforms (Gogonenkov et al., 1984, Igoshkin and Shlezinger, 1990a, 1990b; Slezinger, 1998), which can be confidently correlated with the relative sea-level rises and falls, respectively. Main volumes of clinoform bodies accumulated precisely under the low sea-level stand due to enhanced transport of detrital material from provenance.

In their works, P.R. Vail and his colleagues emphasized that their approach allows discrimination of the relative sea-level changes only. We should repeat that recognition of eustatic components in the latter requires statistical processing of extensive database to eliminate the regional factor of vertical tectonic movements in sea basins and adjacent regions, which result in regressions or transgressions when sea level is practically constant. Volozh and his colleagues believe that depicting the RSLF trend and trend of the basin floor subsidence under influence of epeirogenic movements and isostasy it is possible to determine the eustatic component avoiding a complicated procedure of statistical data processing. On the other hand, they justly note that epeirogenic movements responsible for relative sea level changes involve large crustal blocks (regional) or even continents (global). These movements have nothing in common with contemporaneous tectonic and isostatic factors that lead to subsidence or uplift, deposition or erosion of sedimentary cover in a basin, thus determining the cover structure (Mikhailov and Shlezinger, 1989; Gladenkov and Shlezinger, 1993). Tectonic movements responsible for the RSLF involve usually spacious regions of the Earth surface and are relatively short-term, being of insignificant amplitude (a few to several tens meters occasionaly). They are detectable in areas of transgressions and regressions based on geological data and detailed paleogeographic maps. Artyushkov and Chekhovich (2000) also relate the RSLF with these movements.

Finally, the last point remains. Volozh with colleagues assert that results of sequence-stratigraphy studies put forward a necessity to revise many sedimentation models with their correction for geocratic (low sea-level stand) and thalassocratic (high sea-level stand) epochs. At the same time, they leave aside in fact, the factor of tectonic movements responsible for deposition and destruction of sedimentary (sedimentary–volcanogenic) covers. Therefore, geocratic and thalassocratic epochs only complicate the tectonic impact on sedimentation: they provoke deposition of diverse facies, whereas the depth and genesis of sedimentary basins are determined by diverse tectonic movements alone. Schematic models of sedimentary basins presented by Volozh et al. distort their real structure that is objectively established based on data of seismic sounding and drilling.

It should be noted to our regret that sequence stratigraphy has so far no objective tools for determination of the RSLF and their eustatic components. The approach proposed by Volozh with colleagues is unconvincing and can result in misleading interpretations by scientific and practical works. Sequence stratigraphy provides opportunity to define, only locally and with a great caution, sedimentary bodies corresponding to low, transgressive, and high sea level stands, which can be valuable for geological practice. Bodies of the first type enclose frequently reservoirs beds for oil, while the second ones represent caps of the latter (Shurygin et al., 1999). Determination of global eustatic component in the RSLF is a large scientific problem of great significance (Zakharov et al., 1998). The necessary criteria can probably be elaborated by analysis of regional and global transgressions and regressions (Yanshin, 1973) with due account for recent stratigraphic achievements. It is necessary to pay attention again to the dominant role of low-amplitude tectonic movements in the RSLF origin, as is convincingly shown by Artyushkov and Chekhovich (2000). It is conceivable that the thorough analysis of the RSLF trends (sow-toothed and smoothed) will open in the future an opportunity to discriminate their eustatic and regional tectonic components. At any rate, this problem needs to be investigated further. Expectable data can shed light on fundamental and practical aspects of sequence stratigraphy.

The attempt of Volozh et al. (2004) to contribute to the problem solution deserves attention, although we cannot agree with their interpretations.

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