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Lowstand Systems Tract – A Problematic Stratigraphic Unit

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Introduction

Fifty years ago, Hollis Hedberg, the father of modern stratigraphic practice, wrote a seminal paper on stratigraphic classification and terminology (Hedberg, 1958) and he emphasized that these subjects are "particularily important in petroleum geology". Hedberg stressed the need for precise definitions of stratigraphic terms so as "to allow ready communication and clear understanding" and to avoid "wasted time, futile controversy and pointless discussion". As he noted, "Confusion results from ill-defined terms which are used with a certain meaning by one man and with a different meaning by another". Hedberg (1958) also highlighted the need to avoid "the mixing of the objective and the subjective in our terminology" and lamented "the millions of hours wasted in stratigraphic controversy" merely as a result of such a mixture. The stratigraphic principles and pitfalls outlined by Hedberg (1958) are very relevant for current, somewhat vociferous, debates in sequence stratigraphic classification and terminology.

Lowstand Systems Tract as a Problematic Stratigraphic Unit

Much of sequence stratigraphic classification and terminology in use today was introduced in SEPM Special Publication 42 (Wilgus et al, 1988). One sequence stratigraphic unit which embraces all the problems which Hedberg (1958) warned against is a lowstand systems tract (LST). It is used in different ways by different authors and its definition and delineation commonly depend on both objective, material-based features as well as highly subjective, time-based ones. As predicted by Hedberg (1958), this combination of variable usage and the mixing of objective features with abstract, time-based concepts for the lowstand systems tract has resulted in substantial miscommunication, misunderstanding and misinterpretation.

Original Definition of LST

A lowstand systems tract was first defined and introduced as a specific type of sequence stratigraphic unit by Van Wagoner et al. (1988) and was more fully described by Posamentier and Vail (1988) in the same volume. In these publications, the LST was conceived as a stratigraphic unit bound by the sequence boundary below and the transgressive surface above. This overall approach to defining an LST was reasonable because sequence stratigraphic units are primarily defined by means of the specific sequence stratigraphic surfaces which bound them. However, this definition resulted in some confusion because it was not clear as to what specific types of surface(s) comprised "the sequence boundary" which defined the lower boundary of the unit.

Based on their published diagrams, it is apparent that the lower boundary of an LST in a shelf/slope basin setting is subaerial unconformity on the shelf, a submarine unconformity on the slope and the base of submarine fan deposits in the basin (e.g. Van Wagoner et al, 1988, Fig. 2; Posamentier and Vail, 1988, Fig. 3).

These surfaces were simply lumped together as "the sequence boundary". The upper bounding surface for the LST, the transgressive surface, is a reasonably well defined and characterized, material-based surface. In current terminology, the LST of Van Wagoner et al (1988) can be defined as a sequnce stratigraphic unit bound at the base by a combination of a subaerial unconformity, a slope onlap surface and the base of submarine fan facies and at the top by the maximum regressive surface.

Van Wagoner et al's (1988) definition and characterization of an LST in a ramp setting also resulted in significant uncertainty as to what specific type of surface(s) constituted the basal boundary of the unit. In this case, the lower boundary of an LST was again "the sequence boundary" but the authors provided no information as to what specific type(s) of surface comprised the sequence boundary basinward of the termination of the subaerial unconformity. The boundary was simply drawn as a nondescript line in a succession of shelf mudstones (see Van Wagoner et al, 1988, Figure 3).

In summary, the LST as defined, characterized and illustrated by Van Wagoner et al (1988) and Posamentier and Vail (1988) left much to be desired. In a shelf/slope basin setting, such a unit could be delineated on the basis of objective, material-based surfaces which can be recognized by empirical analysis. However, the use of a highly diachronous, facies contact (base submarine fan), which is a lithostratigraphic rather than a sequence stratigraphic surface, is not an appropriate defining basal surface for an LST. For a ramp setting, the lack of a recognizable, material-based surface basinward of the termination of the subaerial unconformity for the base of an LST precludes the use of an LST as defined by Van Wagoner et al (1988) in that setting.

Alternative Definitions of LST

Hunt and Tucker (1992) proposed a revised definition of a lowstand systems tract by changing the defining basal surface of the unit. They introduced the use of highly subjective, time-based surfaces into sequence stratigraphy and employed the time surface equivalent to the start of base level rise as the basal surface of an LST. This time-based surface is sometimes called the "correlative conformity" (CC) (e.g. Helland-Hansen and Gjelberg, 1994). Notably, this alternative definition for an LST combined a material-based, upper boundary (transgressive surface) with an abstract, time-based, lower boundary (CC). An LST defined in this way is a good example of a mixture of the reasonably objective with the highly subjective.

Posamentier and Allen (1999) proposed a third method of defining an LST and again changed the type of surface which defined the base of an LST. They employed the time surface at the start of base level fall, which had been called the basal surface of forced regression (BSFR) by Hunt and Tucker, 1992), for the basal boundary. Thus like, Hunt and Tucker (1992), Posamentier and Allen (1999) combined an objective, material-based upper boundary with a very subjective, time-based lower boundary.

Misinterpretations of an LST

Attempts to use an LST have most often resulted in badly chosen stratigraphic surfaces being employed as its basal boundary. One of the most common inappropriate surfaces used as the basal boundary of an LST is a highly diachronous, facies boundary between a low energy shelf deposit (e.g. shale/siltstone) and an overlying, higher energy deposit (e.g. sandstone) (e.g. Mellere and Steel, 2000). In a shelf/slope/basin setting, a maximum regressive surface is commonly mistaken for a CC and used as the basal boundary. In such cases, the designated LST is actually part of the lower portion of the transgressive systems tract. Such unsuitable delineations of an LST lead to misinterpretations of facies relationships and depositional history as well as to potentially bad exploration decisions.

Conclusions

The LST is a very problematic unit because:

1) The term is used for three different types of stratigraphic units which guarantees confusion and miscommunication.

2) In one definition, a highly diachronous, lithostratigraphic surface is used as part of the defining basal boundary. In the other two definitions of an LST, highly subjective, time-based surfaces are employed as the defining basal surface. Thus, no matter which definition of an LST is applied, there will be problems with delineating the basal boundary of the unit. Such difficulties often lead to the use of unsuitable bounding surfaces, unreliable correlations and misinterpretations of depositional history, all of which in turn do not allow optimal exploration decisions to be made.

For an LST to become a useful sequence stratigraphic unit, the sage advice of Hedberg (1958) must be heeded. If it is deemed that an LST is a worthwhile unit, it needs to be redefined such that an objective, material-based surface(s), which is well characterized on the basis of observable, physical properties, is employed as the defining basal boundary. Until this Hedbergian requirement is met, it is recommended that stratigraphers not try to delineate and map an LST. Such an activity may be hazardous to exploration efforts.

References

Hedberg, H., 1958, Stratigraphic classification and terminology. AAPG Bulletin, v. 42, p. 1881-1896.

Helland-Hansen, W. and Gjelberg, J., 1994, Conceptual basis and variability in sequence stratigraphy: a different perspective. Sedimentary Geology, v. 92, p. 1-52.

Hunt, D. and Tucker, M., 1992, Stranded parasequences and the forced regressive wedge systems tract: deposition during base level fall. Sedimentary Geology, v. 81, p. 1-9.

Mellere, D. and Steel, R., 2000, Style contrast between forced regressive and lowstand/transgressive wedges in the Campanian of north-central Wyoming (Hatfield Member of the Haystack Mountains Formation). In: Hunt, D. and Gawthorpe, R., (eds.), Sedimentary responses to forced regressions: Geological Society of London, Spec. Pub. 172, p. 141 – 162.

Posamentier, H. and Vail, P., 1988, Eustatic controls on clastic deposition II- sequence and systems tract models, In: Wilgus, C., Hastings, B.S., Kendall, C.G., Posamentier, H.W., Ross, C.A. and Van Wagoner, J.C., (eds.), Sea level changes: an integrated approach: SEPM Spec. Pub. 42, p. 125-154.

Posamentier, H. and Allen, G., 1999, Siliciclastic sequence stratigraphy – concepts and applications: SEPM Concepts in Sedimentology and Paleontology, # 7, 210 p.

Van Wagoner, J.C., Posamentier, H.W., Mitchum, R.M., Vail, P.R., Sarg, J.F., Loutit, T.S. and Hardenbol, J., 1988, An overview of the fundamentals of sequence stratigraphy and key definitions, In: Wilgus, C., Hastings, B.S., Kendall, C.G., Posamentier, H.W., Ross, C.A. and Van Wagoner, J.C., (eds.), Sea level changes: an integrated approach: SEPM Spec. Pub. 42, p. 39-46

Wilgus, C., Hastings, B.S., Kendall, C.G., Posamentier, H.W., Ross, C.A. and Van Wagoner, J.C., (editors), 1988, Sea level changes: an integrated approach. SEPM Spec. Pub. 42, 407 p.