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# INCORPORATION OF SEQUENCE STRATIGRAPHY IN GAS RESERVOIR CORRELATION: A CASE STUDY

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**Abstract**

The application of sequence stratigraphy to resolve the miscorrelation between different genetic units in reservoir characterization in a gas field of Surma Basin is dealt with. Interpretation of available seismic and wireline logs (gamma ray, resistivity, density and neutron porosity) give the sequence stratigraphic correlation of reservoir sands. The reservoirs geometry, its extent, seal architecture and trapping styles have been revealed better with this correlation. There is juxtaposition of two reservoir sands, namely A1 and A2. A1 is located at older highstand sand, whereas A2 is in the younger lowstand sand. Lithostratigraphically they might be same but sequences stratigraphy reveals that they are different and deposited at different times. Moreover, the concept reveals that lowstand sand has better reservoir quality than any highstand and transgressive sand.

*Key words*: Reservoir correlation, Sequence stratigraphy, Channel sand, Incised valley

## Introduction

Bengal Basin is one of the thickest sedimentary basins in which Mio-Pliocene Surma Group is the main reservoir. Total recoverable proven and probable gas reserve of 26 gas fields in Bengal Basin has been estimated to be at 27.12 TCF of which 12.45 TCF were produced leaving only 14.55 TCF. Gas demand of the country has already surpassed about 3200 million cubic feet per day whereas the average supply of gas is around 2,700 MMCFD (Petrobangla Annual Report 2016). The Surma Basin is the Sub-basin of Bengal Basin located at the NE Bangladesh, which is the most important gas rich zone. Previous works in the Surma Basin has yield lihostratigraphic and structural analysis along with the evolution of petroleum prospect. Therefore, under this situation, revising all the gas fields with new concept of sequence stratigraphy is very necessary which has always been neglected because sequence stratigraphic correlation resolves better than the miscorrelation between different genetic units. Sequence stratigraphy subdivides the rock record into genetically related packages of strata (bed, bedset, parasequence, parasequence set, sequence) that are deposited at the same depositional condition at the same time (Fig. 1).

In contrast to sequence stratigraphy, lithostratigraphy has nothing to do with an interpretation of trends or depositional processes. It is simply the science that subdivides a sedimentary rock package into its most obvious lithologies (rock type). For instance in

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similar depth, two wells may find sand but those may not be genetically similar. In lithostratigraphic correlation, there may be excellent lateral connectivity between these two sands but in chronostratigraphic (sequence stratigraphic) correlation, they might be individual dipping clinoforms, gradually pinching out within the prodelta sand (Fig.1).

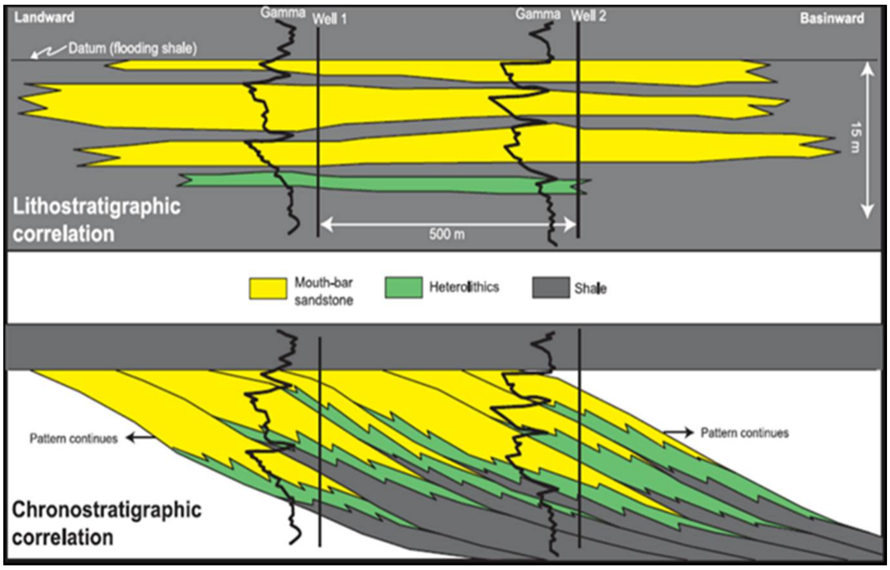


Fig. 1. Lithostratigraphic vs chronostratigraphic correlation (Source: Roger 2013).

Sequence stratigraphic correlation of reservoirs honors this depositional trend and reveals the sand distribution of the gas field, which will be later used for the future development. It is very important to know the depositional trend of major reservoirs in a field because paleo depositional environment gives an idea about sand geometry and its lateral extent. The main objective is to interpret the reservoir sand of the gas field in terms of sequence stratigraphic correlation, which is necessary for gas field development. Some crucial information about reservoir such as where to drill, from which sand to produce, which sand will have better quality etc. should be known before any gas field development which can be done by providing sequence stratigraphy. The reservoir geometry, its extent, sealing architecture and trapping styles can be predicted better with this approach, which may be significant to oil companies for accurate stratigraphic prediction. In addition, it will provide much information in relation to suitable hydrocarbon plays in Surma Basin.

*Study area and data set:* The gas field is located about 40 km south of Sylhet city and approximately 200 km NE of Dhaka, the capital of Bangladesh. It is located in the Moulavibazar district (Fig. 2). It lies in the south-central part of Surma Basin. This field is about 30 km long and 8 km wide. It is a surface (reverse faulted) anticline in the area occupied by low hillocks. Thirteen seismic lines and two wells with all available data (gamma, neutron-density, sonic, resistivity) were used.

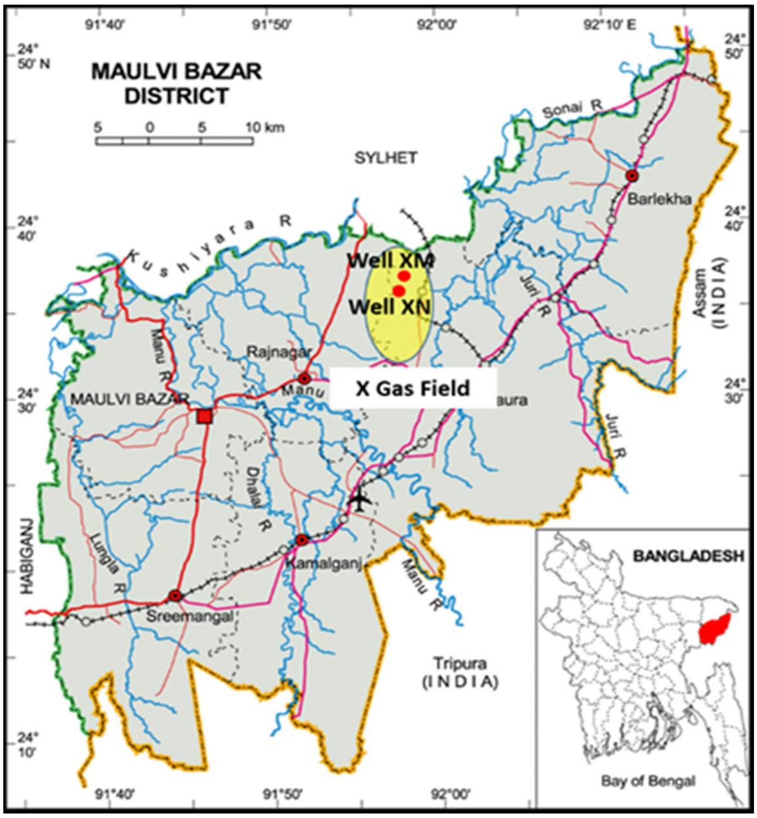


Fig. 2. Location map of the study area showing wells as well as the gas field boundary.

## Methods

The key stratigraphic surfaces i.e. sequence boundary (SB), transgressive surface (TS) and maximum flooding surface (MFS) (Fig. 3) were interpreted separately in wireline log data and seismic. The using reference schemes were Markel (1979), Emery and Myers (1996) and Rider (2002) for wireline log and Mitchum and Vial (1977), Vail *et al*. (1977), Van Wagoner *et al.* (1990), Emery and Myers (1996) and Posamentier and Allen (1999) for seismic interpretation. In the Well Log, SB was placed at the sharp based blocky or coarsening upward (CU) log shape comprising lowstand system tract (LST) till the overlying TS whereas TS was placed at the base of fining upward (FU) log shape followed by the LST. This log pattern develops TST till the MFS. MFS picked at the maximum shale value or maximum gamma ray value. In the seismic, SB was interpreted from onlap, truncation relation whereas MFS was interpreted from downlap. Transgressive surface could not be interpreted on seismic due to data limitations. However, TS on seismic was drawn at the TS point on well after seismic to well tie. Finally, both interpretations (well and seismic) were tied up using synthetic seismogram to obtain fieldwide stratigraphic configuration of the stratigraphic surfaces. Then, the gamma ray (GR), spontaneous potential (SP), resistivity log (LLD), and density (PHID) logs have been used to categorize the lithology of the prospective zones, to discriminate and correlate reservoir from non-reservoir units.

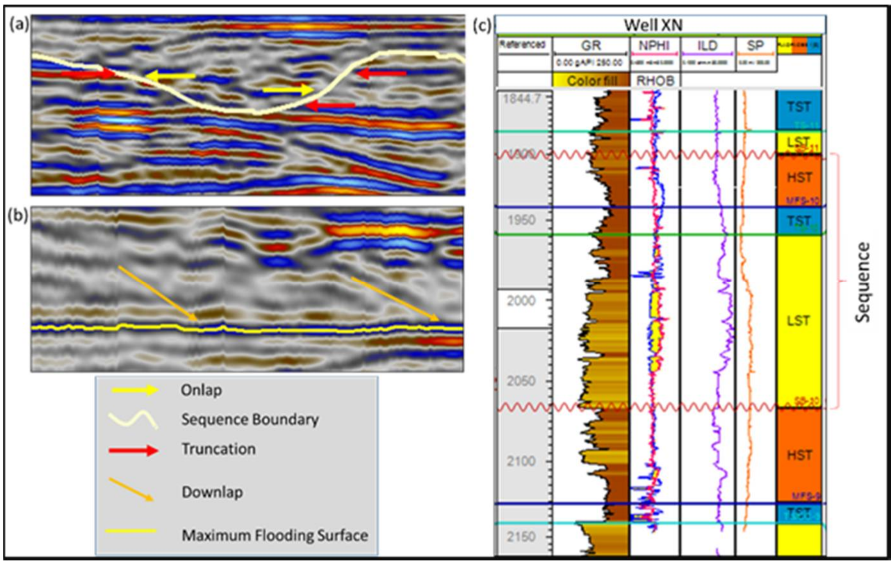


Fig. 3. Identification of key stratigraphic surfaces in the seismic and wireline log. (a) Identification of sequence boundary, (b) and maximum flooding surfaces, (c) Identification of sequence boundary, transgressive surface and maximum flooding surface and their comprising sequence in the wireline log.

Although resistivity log is a good indicator of the presence of hydrocarbon, a suit of log gives a realistic interpretation of reservoir. Therefore, a possible suit of logs i.e. neutron-density and resistivity log (LLD) in combination with GR log were used to identify main reservoir intervals and differentiate between hydrocarbon bearing and non-hydrocarbon bearing zones. Gas zones show low gamma ray value, very high resistivity and sonic values for sand and negative N-D separation for containing hydrocarbon.

## Results and Discussion

Well XM and XN were approximately 1.7 km away from each other and penetrated two gas sands A1 and A2, respectively (Fig. 4). A1 reservoir is composed of highstand sand and bounded by sequence boundary SB-9 at the top. This 15 m thick sand shows very low gamma values, high resistivity and sonic values. The adjacent reservoir A2 in the incised valley is thicker (100 m) and composed of lowstand stacked channel sand, which is coarser than A1 sand. The log responses from this A2 sand show very low gamma ray value, negative N-D separation, and a very high resistivity value. The log shape of A1 sand shows opening and coarsening upward trend corresponding to highstand sand where A2 sand has blocky nature of lowstand stacked channel sand. In addition, sequence boundary (SB) 9 eroded the A1 sand from the well XN and above it, A2 sand was deposited.

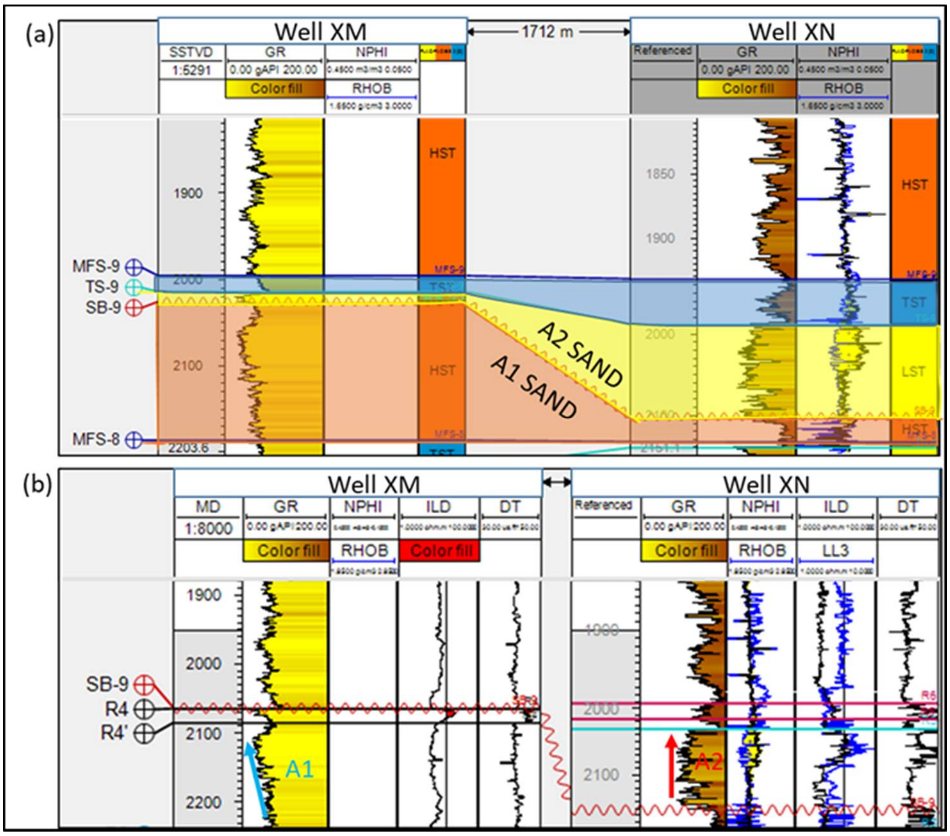


Fig. 4. (a) Well correlation of XM and XN considering sequence stratigraphic concept, flatten on MFS 9, (b) log response of A1 and A2 sands.

In the seismic, their extension can easily be understood. The A2 reservoir is only confined within the incised valley whereas A1 reservoir extends at both sides of the valley (Fig. 5).

A1 sand belongs to the erosional remnant of highstand regressive sand (Figs 4 and 5) whereas A2 is located in the incised valley filled with lowstand stacked channel sand. In terms of reservoir quality lowstand channel stacked sand is better than highstand sand (Parvin *et al* 2019). The log response also reveals so, A1 composed of coarsening upward parasequence set whereas A2 is composed of stacked channel sand. In addition, very low gamma ray value and negative N-D separation compared to A1 as well as hydrocarbon separation in resistivity log in the A2 indicate that this lowstand sand has better reservoir quality than highstand A1 sand. Moreover, gas saturation at the location of A1 and A2 has 35 and 65%, respectively (BAPEX).

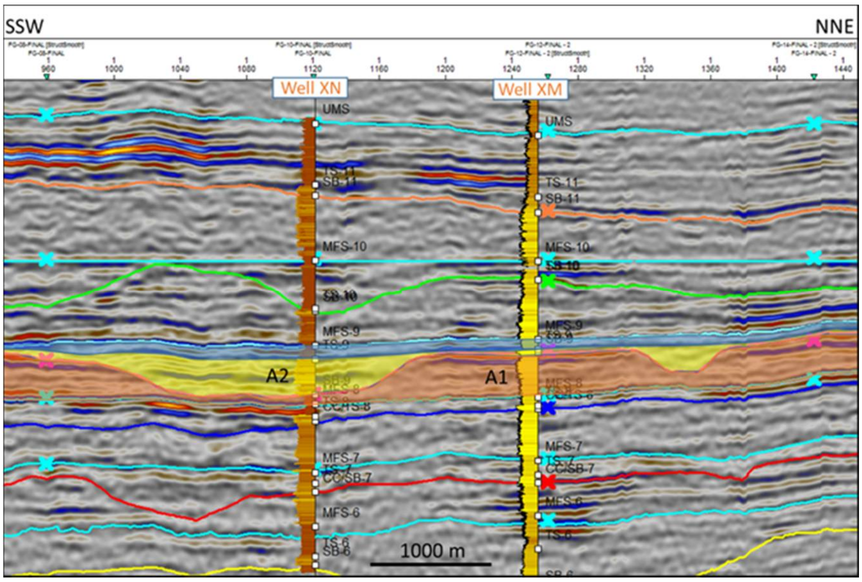


Fig. 5: Identification of the field wide extent of reservoir A1 and A2 in the seismic line-5 after seismic to well tie.

However, in lithostratigraphic correlation, these two sands might be considered as single sand when they were correlated with sand tops although practically they are different sand deposited at different geological times at different conditions. A1 is older than A2. Initially A1 was deposited extensively during highstand time when rate of rise of seal level started decreasing at a rate where sediment supply became equal or greater than the accommodation space. Then during the next falling stage, a sequence boundary developed through erosions, incisions of the highstand sand (Fig. 6). This sequence boundary produced a deep incised valley leaving erosional remnant of previous highstand sand (A1) at both sides of the valley. Later the valley was filled by stacked channel sand and formed A2 reservoir. Then the A1 and A2 were capped by transgressive shale at the transgressive period. Thus, they are genetically different sands where A1 is older than the A2 and the lowstand A2 holds better reservoir quality. This true architecture has been resolved only because of sequence stratigraphic correlation. The correlation has explained the stratal geometry of reservoir sand and related them with depositional pattern and thus reduced the risk of miscorrelation between two different genetic units A1 and A2 and helps to find out the better reservoir resolution.

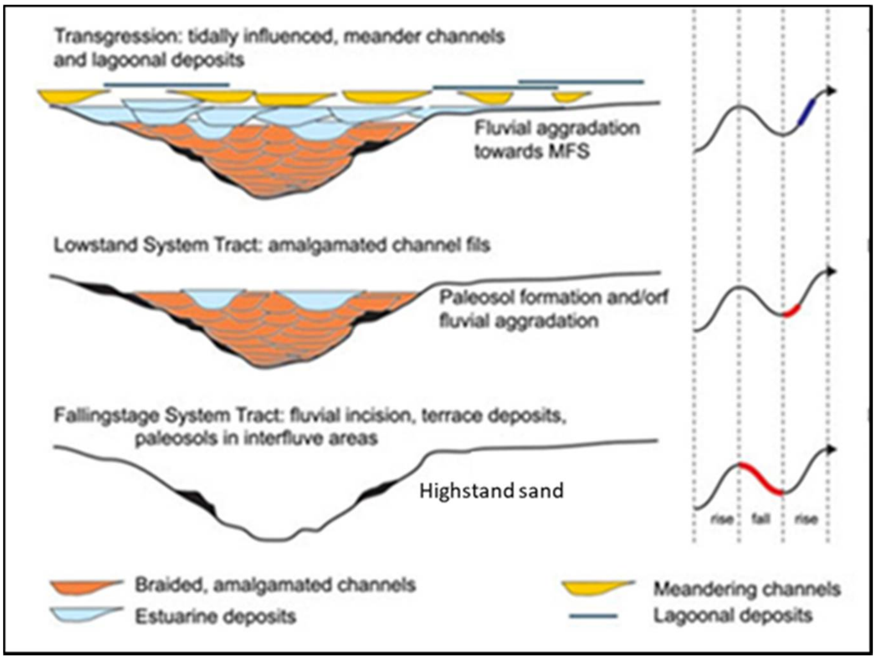


Fig. 6. Illustration of the generation and filling of an incised valley with sea-level cycle (Source: Boyed *et al* 2006).

## Conclusion

Sequence stratigraphic correlation of reservoirs honors the depositional trend and reveals the sand distribution of the gas field. The sand fill incised valley complex holds (A2) better reservoir properties than highstand sand reservoir (A1). Sequence stratigraphic correlation should be considered in all the gas fields of a basin for better understanding of reservoir geometry, which will later be useful for the future development.

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