

# Sedimentary environments and sequence stratigraphy of basal Quartzite of the Mila Group (Fasham Formation), Central Alborz

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## Introduction

Siliciclastic deposits of basal Quartzite of the Mila Group in Central Alborz, called Faham Formation in this research, were studied in Shahmirzad, Tueh-Darvar, Mila-Kuh and Deh-Molla sections in order to interpret depositional environments and reconstruct the sequence stratigraphic framework. Based on facies characteristics and stratal geometries, the size of bedforms, sedimentary structures and their complex arrangement, erosional base, predominantly sandy grain size, the height of the sand bodies together with evidences of the tidal action such as extensive cross-stratified sandstone, tidal bundles, reactivation surfaces and mud drapes, the siliciclastic successions of the Fasham Formation are interpreted to be deposited in a tide-dominated open-mouthed estuarine environment. During the initial inundation of the present-day Alborz region in the early Middle Cambrian time, siliciclastic deposits formed in open-mouthed estuarine. Basal sequence of the Middle Cambrian deposits is composed of a transgressive systems tract (TST) comprising the basal siliciclastic-dominated succession of the Fasham Formation and a carbonate-dominated highstand systems tract (HST) within the lower part of the Deh-Sufiyan Formation. It records the drowning of the terrigenous sources and subsequent establishment of the carbonate system. Based on sequential infilling model for open estuaries during transgression and initial flooding, tidal flats were developed along the margin of the sea and sandy dunes formed along the central part of the estuary and their lower surface was interpreted as a subaerial unconformity formed due to lowstand erosion. The last stage of infilling involves the development of sand bars that gradually migrated towards the open sea until they completely occupied the mouth of the open estuary.

## Material & methods

The Palaeozoic succession in the central Alborz has been divided, in ascending order, into the Zaigoon, Lalun, Mila, and Lashkarak formations. Based on studies by Geyer *et al* (2014) and Peng *et al.*, (1999), the Mila Formation as traditionally applied shows numerous inconsistencies in definition and physical properties which require a complete lithostratigraphic revision. A new lithostratigraphic scheme for the Cambrian–Ordovician strata of the Alborz have been proposed by Geyer *et al.* (2014). They suggested to retain the term “Mila Group” for the lithostratigraphic unit that comprises the Fasham Formation (Base Quartzite), the Deh-Sufiyan Formation (members 1 to 2), the Deh-Molla Formation (members 3 to 4) and the Lashkerak Formation (member 5). Four stratigraphic sections of the Fasham Formation are described and measured in order to interpret depositional environment and sea level changes. These sections are (from west to east): Shahmirzad, TuyehDarvar, Mila Kuhe, and DehMolla. All sections were lithologically logged bed-by-bed according to color, grain-size, sedimentary and biogenic structures, geometry and fossil content. The results, 150-km-long NE–SW transect, provide a two-dimensional control of the changes in thickness and lithofacies in an approximately down-dip direction.

## Results, discussion and conclusion

The size of the bedforms, the sedimentary structures and their complex arrangement, the erosional base, the predominantly sandy grain size, the significant height of the sandbodies together with the evidences from tidal action such as extensive cross-stratified sandstone, tidal bundles, reactivation surfaces and mud drapes, suggest deposition siliciclastic-dominated succession of the Fasham Formation in a tide-dominated open-mouthed estuarine environment (Bayet-Goll and Neto de Carvalho, 2015). Such large tidal sandbars are characteristic of the seaward portions of most macrotidal environments (Dalrymple *et al.*, 1992). Tidal sand bars are particularly

common in lower intertidal and subtidal zones of macrotidal estuaries and deltas (Dalrymple *et al.*, 1992), where tidal flows reach a maximum. These tidally dominated estuarine deposits have a landward-stepping character as they can be seen onlapping on the basal sequence boundary (palaeosol horizon) in a landward direction. At the seaward end of the tidally dominated estuarine deposits of the Fasham Formation, the staking pattern of facies association is implied by the seaward shift of large tidal sandbars into subtidal carbonates of the Deh-Sufiyan Formation.

It seems that the rise of eustatic sea level in the Late Proterozoic and Early Cambrian resulted in a broad marine carbonate platform in a number of intracratonic and marginal seas (e.g., Bayet-Goll *et al.*, 2014). In mixed carbonate-siliciclastic systems, basal part of the Mila Group, because of siliciclastic sediment supply overwhelms and suppresses carbonate productivity during the lowstand or transgression, siliciclastic sedimentation of the Fasham Formation commonly replace lowstand or early transgressive deposits in platform carbonates (Kwon *et al.*, 2006). In other words, during the initial inundation in the Early Middle Cambrian in the Mila Group, siliciclastics deposits formed in open-mouthed estuarine. Sequence 1 of the Mila Group is bounded at the base by a subaerial unconformity formed due to lowstand erosion marked by a palaeosol horizon or tidal ravinement surface cut by tidal currents in transgressive river-mouth settings during shoreline transgression (Catuneanu, 2006). Sequence 1 records the drowning of the terrigenous sources and subsequent establishment of the carbonate system. This sequence is composed of a transgressive systems tract (TST) comprising the basal siliciclastic-dominated succession of the Fasham Formation and a carbonate-dominated highstand systems tract (HST) in the lower part of the Deh-Sufiyan Formation. Again, it records the drowning of the terrigenous sources and subsequent establishment of the carbonate system. During transgression and initial flooding, tidal flats developed at the margins and sandy dunes formed along the central part of the estuary (Harris *et al.*, 2002; Bayet-Goll *et al.*, 2014). The last stage of transgressive infilling involves the development of sand bars that gradually migrated towards the open sea until they completely occupied the mouth of the open estuary. During highstand of sea-level, subtidal carbonate production started and rapidly filled the newly created accommodation space.

**Keywords:** Fasham Formation; sedimentary environment; sequence stratigraphy; Middle Cambrian; estuarine; initial flooding.

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