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Sedimentary Environments And Organic Matter Composition of The Holocene Sediments in The Niigata Plain, Central Japan, And Their Implication for Sequence Stratigraphic Interpretation of Incised Valley Fill

AKIKO, OMURA, Shinshu University, Matsumoto; KOICHI, HOYANAGI, Shinshu University, Matsumoto; MAMIKO, YOSHIDA, Niigata University, Niigata; AZUSA, YAMAZAKI, Shinshu University, Matsumoto; MIYUKI, YAMAGISHI, Shinshu University, Matsumoto; and ATSUSHI, URABE, Niigata University, Niigata

Introduction

Degradation, preservation and compositional variation of sedimentary organic matter are controlled by sedimentary environments and sea-level position. We examined the relationship between sedimentary environments, systems tracts and organic matter composition in incised valley fill sediments.

The Niigata Plain is a coastal plain along the Japan Sea and is situated in the central part of the main Japanese Island. Large discharge rivers, Shinanogawa and Aganogawa Rivers flow into microtidal and wave dominated Japan Sea. Holocene sediment in the Niigata Plain is more than 140 m in thickness. It is filling the incised valley formed during the last glacial maximum. The transgression began in 10,000 yrs BP. The incised valley was filled by sand and mud, deposited from fresh water fluvial condition during 15,000 to 10,000 yrs BP. As the transgression progressed the saltwater area expanded after 10,000 yrs BP. In maximum flooding stage, during 8,000 to 6,000 yrs BP, the barrier island system appeared and lagoonal environment expanded in the incised valley. Strand plain system prograded to seaward after 6,000 yrs BP and dunes and marshes have been developed in regressive stage (Kamoi et al., 2002; Yasui et al., 2001).

We drilled 50 m and took successive cores at two sites on the Niigata Plain for the study of facies and sequence analyses, total organic carbon(TOC) and total surfer(TS) analysis, and insoluble particulate organic matter composition. Drilling site SRSN is situated at the central part of the Niigata Plain. Another site KJSN is situated at the northern part of the plain.

Analytical methods

We analyzed grain-size of sediments with a laser diffraction size analyzer (Coulter LS230), total organic carbon content (TOC) with a CHN analyzer Yanaco MT-5 and total sulfur content with a sulfur content analyzer Horiba EMIA-120.

We also analyze organic matter composition. Siliciclastic and carbonate minerals were dissolved with 10 N HC1 and 46% HF in a water bath. We used no sieve or density preparation, which would have artificially affected the organic matter composition. All organic matter preserved in the sedimentary rocks must be collected to support a precise study. Vitrinite, fusinite, cutinite and sporinite are considered to be derived from higher plant debris, leaf or cuticle, and pollen or spore, respectively. Alginite is of algae or marine plankton origin. Amorphous organic matter is subdivided into NFA (non-fluorescent amorphous organic matter), FA(fluorescent amorphous organic matter) and WFA(weakly fluorescent amorphous organic matter) on the basis of their fluorescent character. According to stable carbon isotopic ratios and fluorescent characteristics, NFA, FA and WFA are considered to be of vitrinite or land plants, sporinite or cutinite, and marine plankton in origin, respectively (Omura and Hoyanagi, submitted; Sawada and Akiyama, 1994). Gorin et al (2001) suggests that NFA is formed under anoxic sea-floor condition. Each type of organic matter was then subdivided into particles based on characteristics seen under a reflected-light fluorescence microscope.

Facies and chemical analyses interpretation

SRSN Site: central part of the Niigata Plain (Fig.1)

Bay head delta sediments (below 48.85m) are composed of medium to fine sand intercalated thin layers of silt. Large scale foreset beds represent in thick sand layers. Bay head delta sediments are overlain by estuarine lagoon sediments (48.85 to 42 m), which are composed of strongly bioturbated sand and sandy silt with scattered shell fragments. Discrete burrows include *Paleophycus*, *Skolithos*, *Teichichnus* and *Chondrites*. Low contents of TOC and TS are recognized in this interval. Estuarine lagoon sediments from 42 m to 26.52m are composed of strongly bioturbated sandy silt. Discrete burrows include *Chondrites*, *Teichichnus* and *Thalassinoides*. Small size borrows *Chondrites* abundant. TS content increases from 0.2 to 1.6% upward in this interval. TOC content begin to increase in the upper part of this interval. Estuarine lagoon sediments are overlain by repetitions of fluvial, lagoon and salt marsh sediments (26.52 to 1.83m). Fluvial sediments are mainly composed of coarsening upward succession of silt to sand and upward fining sand layers intercalate peat layers. Bioturbation is not basically observed in fluvial sediments. Estuarine lagoon and salt marsh sediments are composed of strongly bioturbated upward fining succession of sand to sandy silt and bioturbated peat. *Teredolites* burrows are observed in peat layers. Estuarine lagoon sediment is rich in sulfur. An autochthonous fossil of brackish water molluscs(*Corbicula Japonica* Prime) was found at 13.70 m. TOC contents increase upward in this interval.

KJSN Site: northeastern part of the Niigata Plain (Fig.2)
Pleistocene coarse-grained fluvial sediments are found below 39.38m. Slight bioturbation is observed in place. Holocene transgressive surface is recognized at 39.38m. Cores between 39.38 to 35.98m are composed of granules, pebbles and sand and they are interpreted to bay head delta sediments. The sediments are slightly bioturbated. Lower part of this interval includes shell fragments. Bay head delta sediments are overlain by alternating beds of sand and mud from 35.98 to 27.28m and they are interpreted to tidal flat sediments. This interval represent upward coarsening succession. Discrete burrows include *Ophiomorpha*, *Palaeophycus*, *Planolites* and *Thalassinoides*. Estuarine lagoon sediments from 27.28 to 22.0m are composed of shell fragments scattered clay and silt. This interval represents repetition of bioturbated layers and laminated layers. TS content increases upward below 20m in depth. Estuarine lagoon sediments from 22.0 to 15.5m are composed of mostly silt and clay, and yielded shell fragments. This interval also represents repetition of bioturbated layers and laminated layers. Estuarine lagoon sediment is rich in sulfur. High TS content at ~15.5 m in depth indicate temporal inflow of saltwater. Estuarine lagoon sediments are overlain by lake sediments from 15.5 to 11.0m, which are composed of massive sandy silt. Bioturbation is weak, but comparatively strong at 12m. TOC contents increase and TS contents decrease upward in the lake sediments. Fluvial facies are composed of sand with granules, and intercalates sandy silt and peat layers. Bioturbation is not observed from 11.0 to 1.0m.

Systems tracts and environmental changes
The maximum flooding surface(MFS) is set up at the most fine-grained part of clayey silt. Transgressive systems tract(TST) is composed of the bay head delta and estuarine lagoon sediments and their TOC contents are 0.5 to 1%. High stand systems tract(HST) consists of lagoon and fluvial sediment. TOC contents increase upward in HST sediments. TS content of the HST lagoon sediment is higher than that of the TST lagoon sediment. HST lagoon was much stagnant than TST lagoon, because the estuary mouth was closed by the adjacent delta system.

Tidal flat and TST lagoon sediments have high contents of land-derived organic matter, such as vitrinite, cutinite and NFA. NFA increase and vitrinite decrease upward in the tidal flat and TST lagoon sediments. Marine organic matter, such as alginite, is rarely found in bay head delta sediments. Alginite is frequently found in tidal flat and lagoon sediments. The highest contents of alginite are recognized in the maximum flooding stage of KJSN core. HST lagoon sediments have high contents of vitrinite and NFA. The highest contents of NFA represent in the HST lagoon sediments. This phenomenon indicates that the basin floor of HST lagoon was anoxic condition. This fact also conforms high contents of TOC and TS. Fluvial and lake sediments have high contents of vitrinite, cutinite and NFA. NFA decrease and vitrinite increase with coarsening upward facies succession in fluvial or lake sediments.

Conclusion
+ Lagoonal sediment deposited in the estuary was deposited during transgressive stage and early highstand stage.
+ Estuary was gradually enclosed in highstand stage after the maximum flooding stage.
+ Total organic carbon and total sulfur contents are high in central basin sediments of early highstand stage.

+ Land derived organic matter are preserved in the HST lagoonal sediments, since HST lagoon was enclosed and anoxic condition.

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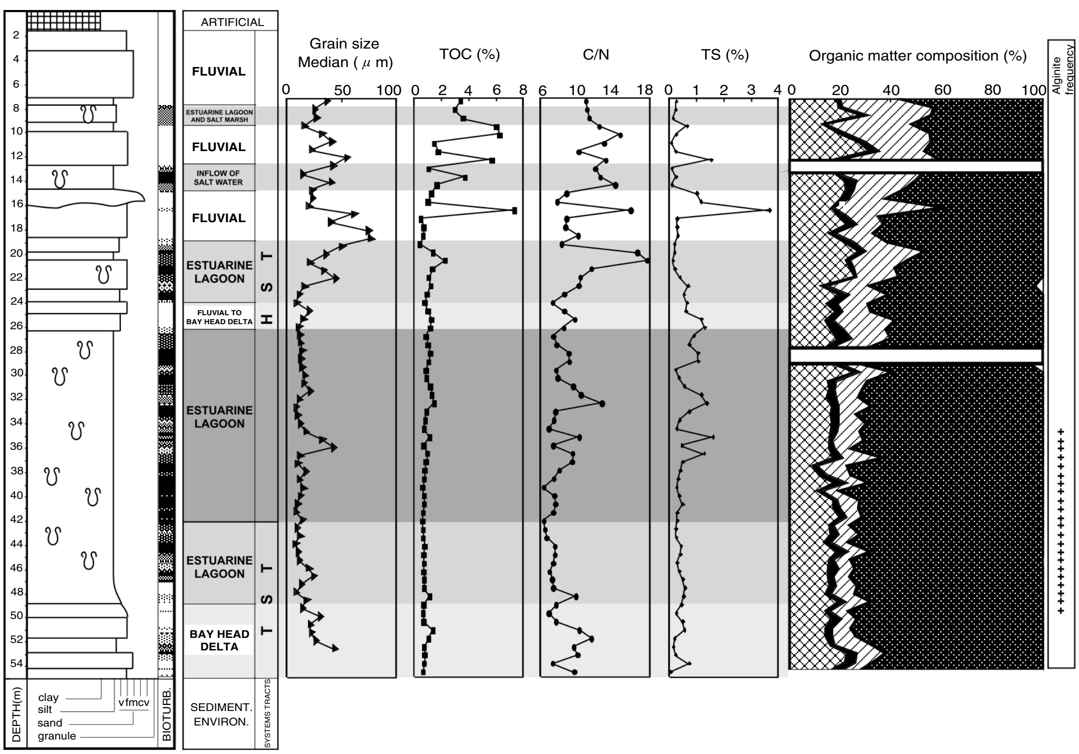

Fig.1 Profiles of grain-size, total organic carbon (TOC), weight ratio of organic carbon content of sediment to nitrogen content of sediment (C/N), total sulfur content (TS), sedimentary organic matter composition and alginite frequency of SRSN. See legend for Fig.2.

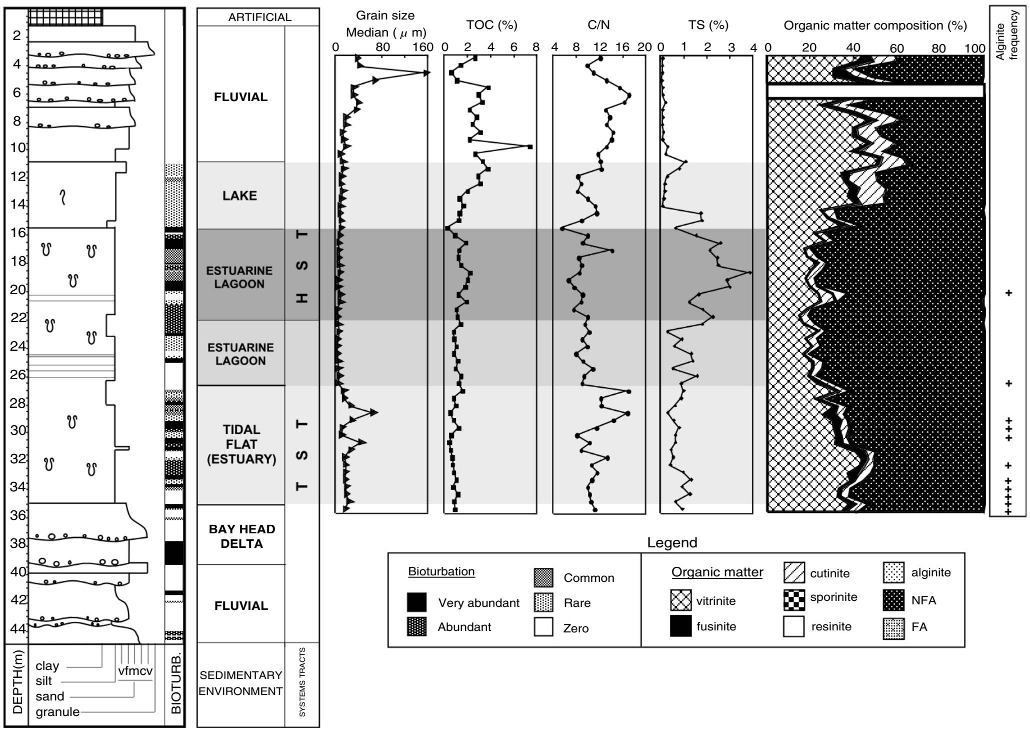

Fig. 2 Profiles of grain-size, total organic carbon (TOC), weight ratio of organic carbon content of sediment to nitrogen content of sediment (C/N), total sulfur content (TS), sedimentary organic matter composition and alginite frequency of KJSN.