Sedimentary environments of Late Carboniferous-Middle Permian in Santanghu Basin, NW China

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Santanghu Basin is an intracontinental superimposed reformation basin from Late Palaeozoic to Meso-Cenozoic, which is located between the Tianshan orogen and Altaides, NW China. It was a continental rift basin from Late Carboniferous to Middle Permian. Based on the data of lithological association, paleontology, element geochemistry, organic geochemistry and stable carbon and oxygen isotopes, integrated with the analysis of geotectonic evolution and marine/continental change, This paper discuss the sedimentary environment of Late Carboniferous-Middle Permian in Santanghu Basin. Considering the development of sedimentary rocks, we deeply studied on the Late Carboniferous Harjiawu Formation and Middle Permian Lucaogou Formation.

(1) lithological association

The Harjiawu Formation consists of basic-intermediate volcanic lavas, pyroclastic rocks and argillaceous rocks deposited during intermittent volcanic eruption. Previous researchers found that dolomicrite and tuffaceous shale is well developed in Lucaogou Formation. Besides, our research group discovers laminated hydrothermal exhalites recently, which is a new type of sedimentary rocks with abundant mantle-originated hydrothermal minerals and microscopic hydroclastic magmatic fragments.

(2) paleontology

Few fossils are recorded in the Harjiawu Formation, mainly leaf fossils. Pollen assemblage and flora indicate a temperate climate. The fauna of Lucaogou formation is dominated by brackish palaeoniscoids and the combination of *Tomiella-Kelameilia- Panxiania* ostracods. The plant fossil and sporopollen assemblages reflect the features of the Angara flora and represents a warm-humid climate.

(3) organic geochemistry

The organic geochemistry features of mudstone in Harjiawu Formation is high Pr/Ph value (between 1.10-3.01), low gammacerane abundance and very low β-carotane abundance, which reflects the freshwater and weak reduction-weak oxidizing environment of the Late Carboniferous.

Characteristics of biomarkers in saturated hydrocarbon of argillaceous rocks in Lucaogou Formation is low Pr/Ph value (between 0.7-1.5), extremely high β-carotene alkanes, gammacerane and long chain tricyclic terpane abundance, which show salinized and reductive environment of the Middle Permian.

(4) element geochemistry and stable carbon and oxygen isotope

Sr/Ba ratio of Harjiawu Formation shale is less than 1.5, and B content is less than 300×10^{-6}. Z values calculated from carbon and oxygen isotope of limestones are between 94.67 and 116.12, with an average of 102.18. It declares low salinity and freshwater environment of Late Carboniferous.

The Sr/Ba ratio in dolomite and tuffaceous shale of Lucaogou Formation is from 10 to 13.86, and B content is 463×10^{-6}. Z values of dolomicrite in Yuejingou outcrop range from 129.03 to 141.43, with an average of 134.6. All the above data suggest that the salinity is high and environment is saltwater in Middle Permian, which is consistent with the conclusion of organic geochemistry.

It is a big controversy of Middle Permian sedimentary environments in the study area; some scholars believe that it is a residual sea environment, others think it is a typical paralic epicontinental lake. Residual sea of Middle Permian is not supported by Freshwater lacustrine of Late Carboniferous. The lithofacies-paleogeography show that the sea has retreated to the Yanchi bay and seawater intrusion may not appear. We suggest the Middle Permian is saltwater lacustrine environment, warm-humid climate, While Late Carboniferous is freshwater lacustrine environment, temperate climate. Water salinization of Middle Permian may be affected by the double impact of climate and ancient hydrothermal activity.

Outcrop-based sedimentary facies and fourth order cyclicity in Miocene small-scale rift basins, Niigata, northeast Japan

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The Niigata sedimentary basin, the most productive oil and natural gas area in Japan, is a Miocene rift basin formed during the extension of the Japan Sea, which eventually developed into a back arc basin. The clastic deposits of the rift phase are exposed in some areas of the eastern margin of the basin such as the Tsugawa area, an elongated depression about 15 km wide, much smaller than the typical rift valley. The basin was also characterized by an extensive acidic volcanism during the rift activity. The purpose of this study was to discuss the characteristics of small-scale rift basins in a coastal setting. This outcrop-based study, which included the geological mapping of the area covering 7 km×3.5 km of the Mikawa region, western part of Tsugawa, northeast Niigata, attempted to reconstruct the sedimentary systems and understand the genesis and development of the basins.

The Miocene in the study area was divided in the Kanose, Tsugawa, and Araya/Igashima Formations, in ascending order. The Tsugawa Formation, covering the basement and the Kanose Formation with an unconformity, mainly consisted of sandstone. This formation received particular attention since it showed a remarkable vertical and lateral variation in the sedimentary facies. The Tsugawa Formation was composed by a depositional system of debris flow-dominated alluvial fan, fluvial (braided and meandering), barrier island, wave-dominated estuary, fan delta, and delta origin. Most of the Tsugawa Formation consisted of alluvial fan and fan delta facies under a coastal setting, with frequent occurrences of debris flow deposits. The Tsugawa Formation showed an overall upward-fining trend, in spite of its cycles of minor progradation and retrogradation.

In the study area, the Tsugawa Formation and the basal part of the Igashima/Araya Formations were divided in three depositional sequences based on their upward fining and coarsening cyclicity. These sequences were called TS1, TS2, and TS3, in ascending order. Previous studies on geologic ages and dinoflagellate ages by the present study indicated an average maximum duration of 0.5–0.23 Ma for the formation of each sequence, which means a fourth-order cycle.

Depending on the probable source area, the variation in sediment thickness, and the fault distribution, small-scale rift basins (<3 km wide) with N-S to NNE-SSW rift-border faults were present in the study area. Overall, the deposits from the steep slopes of the footwall formed thin sedimentary wedges within the half grabens. The distribution of the sequences showed a time lag between the genesis of each basin.

The recognition of fourth-order cycles in this area showed that the rate of relative sea level change was similar to that of clastic supply. In addition, the deposits of the syn-rift phase were not very thick, suggesting that the fault activity and rate of subsidence were small during that period, with a eustasy-influenced sedimentation. However, in general, intermittent fault activity forms progradation and retrogradation in rift basins, so that the sedimentation cycles in this study might be influenced also by tectonics.

Spatio-temporal micro-morphological changes in the inshore part of Eresos beach, Lesvos, Greece

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Field observations and laboratory experiments have been used to observe and model shallow water wave/current ripple morphology. Usually, side scan sonar mapping cannot be utilized due to operational problems in shallow waters close to the coastline. The scope of this study is (i) the observation of the spatio-temporal variability of the seabed morphology and mobility of the bedforms in the narrow inshore area of Eresos beach and (ii) the analysis of the ripple characteristics from sonographs and their comparison with those expected from semi-empirical formulas.

Eresos is a 1.7 km long touristic beach at the NW part of the island of Lesvos (NE Aegean Sea). The coastal area is exposed mainly to S and SW winds, which control longshore sediment transport and enhance coastal erosion mainly in the central and eastern parts of the beach.

An RTK GPS and a single-beam echo-sounder were used for the coastal bathymetric survey. Repeated morphological surveys (4 surveys in a two year period) were carried out with a side scan sonar able to operate in shallow waters (< 10.0 m). Sediment samples and a drop down camera ground-truthed the geophysical results. The wave regime was hindcasted from data from a wind station locally installed.

The study area is characterized by two longshore bars at 1.5 and ~3.0 m depth, rising 0.5 and 1.5 m, respectively. The depth of closure (the most landward depth seaward of which no significant change in bottom elevation occurs) is estimated to be at ~5.0 m, 250 m from the coast. The surficial sediments consist of sand with a mean size of -0.08 to 2.08 Ø, mostly being medium sands, well to moderately well sorted.

Five seabed reflectivity types were distinguished in the sonar images, and their spatial distribution was mapped in each data set. The first two types are related to sediment textural changes and the third to low relief hardgrounds. The fourth type was observed at the central and western parts of the coastal zone, mainly deeper than the 5.0m isobath, resembling sand ribbons oriented almost perpendicularly to the shoreline; this suggests the presence of strong near-bed flows. The fifth type is a typical rippled seabed developing together with the other types, except from the third one. The rippled seabed shows various morphologies suggesting fresh or relict bedforms. The comparative study of the spatial changes in reflectivity types in each mosaic revealed differences ranging up to 100% that may be attributed to hydrodynamics.

The ripple dimensions (length and height) were measured and compared from transects in the sonographs and literature bedform predictors. In the first approach the ripple lengths are 0.55-0.83 m (locally 4.0 m) and their height seems to be less than 0.1 m. According to the literature, lengths are predicted to be 0.1-1.4m and the heights 0.01-0.23 m. Long wave ripples probably suggest relict features with different dimensions from those computed. Also, ripples in deeper waters may be relict, generated during minor storms preceding the sonar observations.

These results provide an example of the spatio-temporal complexity of the micro-morphology across the inshore part of the study area. Similar ripple dimensions are discussed in the literature from field observations using different approaches, in comparable wind/wave and grain-size settings, thus confirming the validity of the results. The presence/migration of bedforms (ripples and ribbon-like features) on the seabed gives a clear indication of the active sediment transport on Eresos beach.

Acknowledgments: This research has been co-financed by ESF and Greek national funds through the operational program “Education and Lifelong Learning” of the NSRF Research Funding Program THALES-ISLA.

The MIS 5-4 transition in sediments from the deep Dead Sea basin

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The Dead Sea and its Pleistocene precursor lakes accurately recorded climate change in the eastern Mediterranean region. The ~460 m long sediment core 5017-1 was retrieved from the deepest part of the lake and archives the regional climate variability of the last 200-250 ka. Here, we focus on the upper part of the Samra Formation (~135-70 ka BP) and the transition into the Lisan Formation (~70-14 ka BP), which includes a layered salt sequence deposited during the MIS 5-4 transition. The analyzed interval of ca 30 m covers a lower ~20 m thick interval of alternating aragonite and detritus **(aad)** accumulated during more humid climatic conditions, which is followed by a ~10 m thick interval of predominantly layered massive halite, reflecting a dryer climate. We present a multi proxy record including micro-facies analysis on large-scale petrographic thin sections, micro-XRF element scanning, grain size and magnetic susceptibility measurements. These analyses allow a high-resolution characterization of the sediments and interpretation in terms of depositional processes and their value as palaeoclimate proxies.

These data show a short-lived (abrupt) dry interval directly before the onset of the relatively humid conditions corresponding to the Lisan Formation, suggesting a millennial-scale dry period. This is in agreement with a previously identified depositional hiatus and associated erosional unconformity in the shallower areas outcropping at the margins of the lake. However, the deposition of glacial-like **aad** sediments prior to this pronounced dry event contrasts to previous analyses on outcrops. These sediments from the deep Dead Sea basin will hence allow understanding and better deciphering the depositional processes in relation with climatic change during the MIS 5-4 transition on centennial and millennial time-scales.

Acknowledgements: Funding by the International Continental Scientific Drilling Program (ICDP), the German Research Centre for Geosciences and the German Science Foundation (DFG grant BR 2208/10-1) is gratefully acknowledged.

Sediment distribution in a cold climate salt-marsh

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Winter sea-ice in cold or subarctic marshes has a significant sediment-transport capacity. In the intertidal zone, sea ice can freeze, pull up and then raft layers of sand, mud, or salt-marsh soil. These processes have been described, but their implications with respect to sediment distribution and marsh evolution is less well documented. Is the sediment distribution in such marshes similar to that of temperate marshes?

The Penouille salt-marsh is located in a microtidal, sandy lagoon at the eastern end of the Gaspé Peninsula, Québec, Canada. It is characterized by important seasonal variations with sea-ice cover from January to March. Sediment distribution in the marsh was investigated by analysing 215 surface samples for grain size and organic matter content. In addition, 10 sediments cores were taken to study marsh history. Lateral marsh evolution was determined over 50 years from historical aerial photographs and vertical evolution over 2 1/2 years with accretion plates.

The Penouille marsh was established about 1000-1200 cal BP in the most landward sector. Long-term accretion rate measured in sediment cores is 0.35-1.0 mm/year, while accretion rate measured since the 1963 ^{137}Cs peak is 1-3 mm/year and accretion rate measured with accretion plates is 3.0 ± 4.7 mm/year. These accretion rates are similar to the present relative sea level rise (1.4 mm/year over 1969-2012), but are lower than the sea level rise expected during the 21st century. The outer marsh edge retreated only slowly, with a marsh area loss of 1 ‰/year from 1975 to 2008.

Grain size gets finer while organic matter content increases locally with elevation on transects from the lagoon to the high marsh. However multiple linear regressions with all marsh samples showed a more complex pattern of sediment distribution. Grain size gets finer and organic content increases with increasing distance from the lagoon inlet, distance from the marsh-lagoon limit, and distance from the closest sediment source (creek, pan or lagoon). Surprisingly, the grain size trend is coarsening with elevation over the whole marsh, which can be explained by ice rafting (ice rafts often get stranded and melt on the upper marsh) and by aeolian transport from the seaward sandy peninsula.

The classical sediment distribution pattern for temperate-climate marshes is only partially valid in cold-climate marshes, where ice rafting produced irregular, spatially highly variable sediment deposits with little grain-size sorting.

This study was funded by Parks Canada.

Drainage network response to transpressional tectonism along a strike-slip plate boundary in Sakhalin, Far East Russia

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The island of Sakhalin in the Russian Far East was the site of Neogene deposition of a thick (5 km) sequence of deltaic sediments, deposited by the Amur River. The deltaic sequence was deposited across an active strike-slip plate boundary, the Sakhalin-Hokkaido Shear Zone, which separates the Okhotsk Plate in the east from the Amur and Eurasian plates in the west. These sediments are now exposed in the exposed in the North Sakhalin Basin, where they are being actively deformed by Pliocene-Recent transpression along the underlying plate boundary. The homogeneous nature of the poorly lithified sedimentary sequence being deformed allows us to investigate landscape evolution along >200 km of the plate boundary in a relatively early stage of the orogenic process. We use fluvial geomorphological indicators, including planform morphology, concavity (θ), steepness indices (k_s) and knickpoint distribution of rivers as evidence for active deformation of the landscape. Tectonics and topography are strongly coupled in this basin, and neotectonic activity can be observed directly from the fluvial landscape. k_s values are strongly correlated with areas of recent and active uplift. Knickpoints are located along active fault planes or in areas of recent drainage capture, where they are associated with low concavity indices. Uplift of transpressional anticlines and disruption of drainage patterns appears to be diachronous, with the deformation front propagating to the northeast through time. This is consistent with plate motion velocity vectors previously recognised in the basin, which show a progressive change from pure translational faulting in north Sakhalin to oblique compression in the south of the island. Minimum uplift and strike-slip displacement rates are 0.63 mm/year and 1.95 mm/year, based on exhumed stratigraphy and offset drainage networks respectively.

Echo-characters seismic and bedforms characterization in the shallow tropical shelf: Areia Branca, NE Brazil

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High resolution (chirp) sub-bottom profiles surveys and sediment sampling were carried out along the northeastern Brazilian continental shelf adjacent to Areia Branca city. This area was selected because it is submitted to intense human activities related to fisheries, oil and salt industry, and nowadays, it is under severe erosion. The study area is inserted in the offshore Potiguar Basin, which integrates the scenery of the Meso-Cenozoic basins of the Brazilian equatorial margin. Neogene lithostratigraphic units (Tibau Formation, Guamaré Formation and Ubarana Formation) constitute the upper part of a large-scale regressive cycle and form a seaward-thickening coastal-shelf-slope-basin system. The used data set includes 78 sub-bottom profiles, 51 bottom sediments samples, bathymetric model and satellite images in GIS database. The integration of these data allowed the identification of four echo-characters seismic and the mapping of five types of bedforms in the study area. Four types of echo-characters were identified revealing the strong relation with the grain size distribution and bedforms. Echo-characters type A is associated with strong reflections of seabed without penetration of acoustic signal in the sandy (siliciclastics sand and bioclastic sand with granules and gravels) bottom areas, typical of the parallel-transverse dunes and flat bottom bedforms. Type B showed high penetration of acoustic signal in the muddy (carbonate marl and carbonate mud) bottom areas with reflections of the acoustic basement delineating erosional surface (laterally-prominent reflector, interpreted as representing the sub-aerial exposure of the continental shelf and limit Pleistocene/Holocene), and filled-incised valley Apodi-Mossoro features. The type C is associated with strong reflections without sub-bottom penetration, being represented by outcrops on the seabed mainly recognized by single or multiple hyperbolae and variation bathymetric of bottom in sand and muddy bottom areas. The type D showed strong reflections of seabed and low penetration of acoustic signal in sub-bottom, characterized by sismofacies with irregular paleo-relief and/or paleo-channels covered by small ripples and parallel dunes of composition bioclastic sand nowadays. These results indicated different sedimentary processes acting in seabed associated with current near the bottom, calm sedimentation and erosion by bottom current. In the sub-bottom the sedimentary processes is associated with erosion, structural and lithological controls possibly correlated with sea level change.

Keywords: Echo-character seismic, bedforms, Areia Branca.

Acknowledgments: This work was supported by PRH-ANP22 (FINEP/MCT/ANP/CTPETRO), Ciências do Mar 207-10 (CAPES), PROBRAL 337-10 (CAPES/DAAD), Grant PQ 303481/2009-9 (CNPq), and PPGG/UFRN.

Sediment-dwelling organisms mimicking laminoid fenestral fabrics in shallow water carbonates

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Laminoid fenestral (LF) fabrics of polygenic origin are commonly encountered in carbonate rocks. They may result from repeated wetting and drying of carbonate mud in supratidal settings, from drying out of cyanobacterial mat surfaces, and/or from degassing of decaying organic material. Arrangement and shape of the fenestrae, as well as the void/sediment ratio are the most important features used in classification. LF-A fabrics are characterized by solid laminoid fenestrae, whereas LF-B fabrics have irregularly laminoid fenestrae. Laminoid fenestral fabrics are common in modern intertidal to supratidal settings and are thought to be indicative of such settings also in the fossil record. However, such structures may also develop in a variety of subaqueous marine and non-marine environments.

We present here a long-since known, but still enigmatic microorganism that mimicks laminoid fenestral fabrics (mainly of the LF-B type) in Palaeozoic shallow water carbonates. *Irregularina* BYKOVA is a poorly know taxon, usually viewed as representing a parathuramminid foraminifer. It occurs in great abundances within mid-Palaeozoic (Middle Devonian to Lower Carboniferous) fine grained bioclastic carbonates, in part with microbial characteristics. Based on the wide range of variations in morphology, a large number of different species within *Irregularina* have been introduced. Species are discriminated by differences in general outline, size, and the presence and number of restrictions and „apertural nozzles“. However, it is important to note that all „species“ of *Irregularina* are defined based on two-dimensional appearance in thin sections; none are based on isolated material. Moreover, the wide range of irregular but transitional external morphologies renders identification of consistent morphotypes impossible. As a consequence, external morphology and size do not represent reliable criteria in species definition within *Irregularina*, thus challenging the high species diversity proposed for this genus. Although the precise systematic affinities of *Irregularina* remain unresolved, our observations strongly suggest affinities to the lobose amoebozoans with a psammobiontic lifestyle based on small-scale sediment grain – organism interactions, as well as burrows associated with *Irregularina*. The high morphological variability is believed to be a result of the motility of *Irregularina*. A flexible, non-rigid outer body membrane appears to permit considerable changes in shape. It is likely that this organic membrane calcified during early rock lithification, and is recognizable in fossils as a dark micritic line. Since the Irregularinidae share certain similarities with Mesozoic Thaumatoporellaceae, including certain Liassic forms directly comparable with certain Devonian irregularinids, not only the mid-Palaeozoic but also Mesozoic laminoid fenestral fabrics perhaps originated from the growth of putative psammobiontic microorganisms.

Depending on *Irregularina* abundance and lithological features, *Irregularina*-bearing facies types might falsely be interpreted as laminoid fenestral fabrics (including loferites). Occuring within microbialites, *Irregularina* can easily be mistaken for microbial growth cavities. All this might cause misinterpretations of the existing facies with regard to water depth and environmental setting. Putative laminoid fenestral fabrics and microbial growth cavities might in fact both result from the activities of *Irregularina* in the interstitial space within the sea floor sediment or on and within microbial crusts.

Sedimentology and Stratigraphic Reconstruction of the Uppermost Miocene-Pliocene Part of the Celebes Molasse, SE Sulawesi, Indonesia

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The Celebes Molasse is well known as weakly consolidated Neogene sedimentary deposits that rest unconformably on pre-Miocene rocks in Sulawesi. It is considered to be a post-orogenic unit and includes numerous poorly defined formations of uncertain Neogene age. This project is concerned with a detailed study of these sediments. New field observations of sediment characteristics (grain size, composition, colour etc.), sedimentary architecture, palaeontology, and palaeocurrent indicators have been collected from the Celebes Molasse across SE Sulawesi.

The architectural elements and lithofacies have been integrated with biostratigraphic data and ichnofacies to interpret the sedimentation history and consider lateral change and correlation across a large area. Our observations indicate that the Celebes Molasse in SE Sulawesi can be subdivided into three units, which we refer to as: (1) a serpentine-rich clastic unit (pre-Latest Miocene), (2) a limestone unit (Latest Miocene – Holocene) and (3) a quartz-rich clastic unit (Late Miocene-Pliocene). The serpentine-rich clastic unit is the oldest Neogene deposit in the sequence and is unconformably overlain by the limestone and the quartz-rich clastic unit.

Here we report some results from the quartz-rich clastic unit. Sedimentation began with a fluvial sequence which includes twenty-three sub-lithofacies (e.g. trough cross-bedded gravel, planar-cross bedded sand, parallel laminated sand, silt and mud, etc.) and were grouped into gravelly, sandy and fine grained lithofacies. Seven architectural elements were also recognised which include: (1) major channels, (2) minor channels, (3) gravelly bars, (4) sandy bars, (5) lateral accretion, (6) floodplain and (7) crevasse splay deposits. The upper part of the sequence is dominated by bioturbated sandstone and mudstone and includes shallow marine limestones. Floodplain deposits also increase upwards.

Interpretation of the quartz-rich clastic unit indicates a fluvial to shallow marine depositional environment. Gravelly to sandy channel and bar deposits with minor mudstone deposits indicate a moderate to high energy fluvial braided system. Multi-storey channel fills and lack of very fine grained floodplain deposits indicate a restriction of accommodation. An equivalent age slumped delta front deposit was observed and indicates relatively rapid sediment accumulation. Subsequent deposition of tidally-influenced fluvial deposits and backstepping limestone indicate a transgressive sequence and terrestrial equivalents are suggested to show a relative increase of finer-grained overbank deposits.

The evolution in time of these sediments may be related to basin-forming tectonic processes. Tectonism caused initial uplift and produced a regional unconformity above the serpentine-rich clastic unit. Following this event there was initially a low amount of accommodation space in which coarse grained fluvial sediments were deposited. With time, high discharge sedimentation occurred, possibly magnified by strong seasonal conditions (e.g. seasonal rainfalls and dry periods) producing flash-flood sedimentation.