Silica Diagenesis in Norian microbialites from the western Tethys platform margins (Italy)

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Norian carbonate successions widely outcropping in the Italian peninsula were dominated by the deposition of the Dolomia Principale (DP) a thick dolomitized carbonate platform formation which witnesses the existence of an epicontinental shelf, interrupted by small intra-platform basins with fault-controlled syn-rift margins, characterized by microbial-serpulid communities which represent the main reef-builders.
A detailed diagenetic study was accomplished on Norian samples coming from the margin-upper slope of different intra-platform basins of the Lombardy Southern Alps (Iseo lake, Brembana, Seriana and Taleggio valleys) and completed for comparison with samples from the Southern Apennines (Picentini mountains and Calabria coastal range). A general paragenesis of the diagenetic events was reconstructed including multiple episodes of dolomitization, calcitization and silicification.
In the Southern Alps outcrops from Lombardy a clear distinction can be made between a dark silica phase (*Black Quartz*) replacing the previously dolomitized biologically-induced microbialites (up to decametre wide and thick, coalescent oncolitic, domal thrombolitic and stromatolitic mounds) and a later translucent silica phase (*Clear Quartz*) cementing the framework pores. Such a distinction could not be made in the Southern Apennines where the quartz displays mostly a dark to rusty appearance.
Microscopically most silica is given by megaquartz (100-300 mm) with patches of microquartz, whereas a radial-fibrous chalcedony texture is observed only in a few Calabria mound samples and in samples of the Riva di Solto Shale Fm. overlying the Lombardy microbial mounds. However, ghosts of an earlier fibrous silica, later recrystallized by megaquartz, are present in all of the studied outcrops.
Oxygen isotope analyses were accomplished on the different petrographic types of silica and on large euhedral quartz crystals of possible hydrothermal origin from the Lombardy Southern Alps. A first population with the highest $d^{18}O$ values (29 to 32 ‰ SMOW) includes all the Southern Apennines samples and the *Black Quartz* from Lombardy. A second population with distinctly lower $\delta^{18}O$ values (17 to 23 ‰ SMOW), includes the *Clear Quartz* and the euhedral quartz crystals from Lombardy. By applying known oxygen fractionation coefficients a low temperature origin (compatible with early diagenesis) and a high temperature origin (compatible with hydrothermal fluid circulation) is suggested for the first and the second population, respectively.
The early diagenetic origin of the *Back Quartz* from Southern Alps is suggested also by the occurrence of reworked and silicified microbialite clasts in the breccia of the uppermost DP and by the presence of primary mono-phase fluid inclusions. These latter coexist with secondary bi-phase inclusions recording temperatures of recrystallization above 180 °C. The high $d^{18}O$ values are therefore the memory of early silica diagenesis preserved despite the complex history of burial and hydrothermalism suffered by the different areas.
The presence of such early silicification in equivalent facies of the broad DP margin and upper slope domains is a strong advocate for a common origin. Three possible sources for early silica in these microbial facies will be discussed: 1) Silica from diagenesis of surrounding clays; 2) Biogenic silica from compaction of lateral basinal sediments; 3) Silica produced in-situ within the microbialites.

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Depositional system in the western Muroto Trough, a forearc basin along the Nankai Trough, Japan, and it influence to estimate recurrence intervals of Nankai earthquakes using the deep-sea turbidites

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Muroto Trough is a forearc basin along the Nankai Trough. Turbidite paleoseismology in Japan originated using a sediment core from the Muroto Trough (Taira and Murakami, 1984). However, no detailed study on the turbidite paleoseismology has been conducted in the Muroto Trough. To understand the recurrence of turbidites in the Trough, we conducted a survey cruise, and collected three piston cores from the western Muroto Trough, where the None submarine canyon opens at the western end of the Trough. From the visual core descriptions, we recognized many fine-grained turbidite beds with sharp and erosional bottom contact and fining-upward grading structure in three cores. Based on radiocarbon age determinations using planktonic foraminiferal tests in hemipelagic mud and identification of tephra beds, the averaged sedimentation rates of three cores range from 33 ~ 70 cm/ky, and increase westward. On the other hand, the recurrence intervals of turbidites range from 72 ~ 1139 years, and increase westward. This means higher sedimentation rate and less turbidite occurrence in the western (proximal) area than in the eastern (distal) area. Most of the recurrence intervals in the eastern core indicate 100 ~ 200 years, which is well-concordant with the recurrence intervals of the historical Nankai interplate earthquakes along the Nankai Trough. This suggests that the deep-sea turbidite is a potential tool to reconstruct the past Nankai earthquakes. Spatial differences on the sedimentation rate and turbidite recurrence can be explained by the depositional system in the western Muroto Trough. Sub-bottom profiling records indicate that a submarine fan occurs at the western end of the Trough, and a submarine channel recognizes on the fan surface. More terrigenous mud supply through the None submarine canyon may contribute higher sedimentation rate in the western and proximal area than in the eastern and distal area. Occurrence of submarine channel on the fan confines the turbidity current, and only the overflowed turbidity currents can make turbidites on the fan. On the other hand, flat and well-stratified acoustic facies suggesting the sheet-like turbidite deposition found in the eastern area. Almost all turbidity currents can generate turbidites under the environment. Thus, it is very important to understand the depositional system of the study area for the evaluation of recurrence of the past large earthquakes from the deep-sea turbidite records.

Reference

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Shallow marine sediment deformation, erosion, resuspension and redeposition by the 2011 Tohoku-oki earthquake and its related tsunami along the Tohoku coast

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To use the sedimentary record as a paleoseismological tool, it is very important to understand what kinds of phenomena have been occurred by a particular earthquake and tsunami. The 2011 Tohoku-oki earthquake was a large and destructive earthquake. Huge tsunami attacked the Pacific coast of the northern Japan. To understand the influence of the earthquake and tsunami to sea floor, we examined the surface sediments in off Sanriku-Fukushima area. Soft sediment deformation recognized as vertically oriented planar structure with their height/spacing ratio of around 5 was found on the outer Sendai shelf near the fault rupture area. Strong ground shaking of sea floor with the predicted PGA of around 500 cm/s2 by the 2011 earthquake formed the deformation structure. On the inner-mid Sendai shelf, change in sedimentary structures and grain size before and after the 2011 earthquake and tsunami was recognized at several locations. Extremely coarse-grained thick sand beds, which created as the result of transport of beach-shoreface sand toward offshore, found at the shoreface-offshore transition zone. Deposition of clean and well-sorted medium-fine sand on the inner shelf floor is another example of the tsunami-related sandy deposits. Homogeneous or parallel laminated mud with upward fining grading structure is a typical example of the tsunami-related muddy deposits on the inner Sendai shelf. The sedimentary structures of the muddy event deposits suggest that the deposits were formed from suspended water masses. Large friction velocity of the 2011 tsunami waves intruding the shallow Sendai shelf eroded and resuspended the inner shelf sandy and muddy surface sediments, and formed the inner shelf event deposits. Thin but homogeneous muddy event beds found on Sanriku and Fukushima shelves suggest that sediment resuspension might occur at the wider area along the Pacific coast of Tohoku. Huge tsunami wave is the candidate for sediment resuspension, but strong ground shaking by the earthquake might contribute the resuspension of the surface sediments. Collapse of the suspended water masses generated turbidity currents, and formed muddy turbidites at offshore areas. Long-distance transport from the outer shelf to forearc basin floor was expected from the benthic foraminiferal assemblages of the muddy turbidite in the forearc basin. These facts indicate that the large tsunami has enough potential to erode and resuspend the shelf sediments, and to form the highly suspended water masses, and further to generate the turbidity currents and to transport sediment grains from shallow water to deep water.

First description of Phanerozoic radiaxial fibrous dolomite

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Petrographic and crystallographic analysis of concretionary carbonate cements ("coal balls") from Carboniferous paralic swamp deposits reveals the presence of radiaxial fibrous dolomite (RFD), a fabric previously not reported from the Phanerozoic rock record. This finding is important because earlier findings of Phanerozoic radiaxial fibrous carbonates are exclusively from calcitic mineralogies. The dolomite concretions described here formed beneath marine transgressive intervals within palustrine coal seams. This is of significance as seawater was arguably the main source of Mg^{2+} ions for dolomite formation. Here, we present data from optical microscopy, cathode luminescence, electron backscattered diffraction, X-ray diffraction and geochemical analyses that characterize three paragenetic dolomite phases and one calcite phase in these concretions. The main focus is on the earliest diagenetic, non-stoichiometric (degree of order: 0.41-0.46) phase I, characterized by botryoidal elongated dolomite built by fibers up to 110 mm wide that show systematic undulatory extinction and converging crystal axes. Petrographic and crystallographic evidence clearly qualifies phase I dolomites as radiaxial fibrous fabrics. Conversely, fascicular optic fabrics were not found. Carbon-isotope ratios ($d^{13}C$) are depleted (between -11.8 and -22.1‰), as expected for carbonate precipitation from marine pore fluids in organic-matter-rich, paralic environments. Oxygen isotope ratios ($\delta^{18}O$) range between -1.3 to -6.0‰. The very early diagenetic nature of these cements is documented by the presence of ubiquitous, non-compacted fossil plant remains encased in phase I dolomites, as well as by the complex zoned luminescence patterns in these fabrics. We argue that organic matter, and specifically carboxyl groups, lowered the thermodynamic barriers to dolomite formation and facilitated $Mg/CaCO_3$ precipitation. The data shown here reveal a hitherto unknown level of complexity with respect to radiaxial fibrous carbonates and are of importance for researchers concerned with dolomites and carbonate petrography in general.

Hundred-meter-scale sediment wave-like stacking pattern of sediment–gravity flow deposits developed offshore of the fandelta, Neogene Aoshima Formation, Kyushu Island, Japan

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In deep-sea environments, sediment waves ranging from hundreds meters to tens of km in wavelength scale are mostly observed. However, detailed sedimentary facies and depositional topographies in such scales have not been reported from outcrops, which could be attributed to limitations in the outcropping and variations in the scales of bed thickness. Neogene forearc basin fills of the Aoshima Formation, which are well exposed along the Nichinan Coast of Kyushu Island in southwestern Japan, consist of alternating hemipelagites and sediment–gravity flow deposits. This formation is located at the offshore region of fluvial–to–slope deposits of the Miyazaki Group, suggesting fandelta deposition. The alternation of the Aoshima Formation consists of a mudstone-dominated turbidite succession and distributes 13 km and 2 km to the north–south and east–west directions, respectively, along the Nichinan Coast. These turbidites, which are sediment–gravity flow deposits observed in the Aoshima Formation, do not exhibit typical Bouma or Lowe sequences. Most of them lack ripple-cross and parallel laminations of Bouma divisions (Tb and Tc). They have been classified into types G, showing graded beds; I, inversely graded beds; and M, massive beds. These types are composed of a combination of massive sections, including HCS-mimics, climbing-ripple cross lamina, spaced-planar lamina, and parallel lamina of Td.

In this study, 35 stratigraphic logs of the alternation along 700 m in the paleocurrent direction were collected. Based on the logs, the cyclic lateral changes in the bed thicknesses and sedimentary facies suggesting sediment waves were found in the study horizon. The patterns of lateral changes in bed thickness and sedimentary structures of the sediment–gravity flow deposits are summarized in the following manner. (1) Depositional topography formed by successive sediment–gravity flow is clearly observed as reliefs of less than 2 m. (2) The sediment wave-like stacking pattern has a wavelength of ca. 400 m. (3) The rip–up mud clasts in the sediment–gravity flow deposits distribute intermittently in a lateral formation, which indicate upstream-ward migration. (4) Finally, the slope gradient of the depositional topography estimated from the stacks of the alternation suggests that the lateral thickening beds are observed at the sites of larger values of the slope gradient. These results suggest that the hydraulic jump of sediment–gravity flows causes a sediment–wave construction induced by self-organized topography.

The Identified Lower Pleistocene "Huge Submarine Landslide Anomaly", Southern Part of Kanto Basin, Japan

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The Southern Part of Kanto Basin located in the Boso Triple Trench Junction close to the west. Paleogene and Neogene deep see clastic rocks and sediments are dominated in E-W trends folding structures. Otherwise monoclinic Plio- Pleistocene is named Kazusa Group which reserved water dissolved biogenic type natural gas producer in middle to northern part of Boso Peninsular. It is often discussed as the fossil remain of methane hydrate resources.
Our ACRG have been carried out detailed geological mapping in the southern most part of Boso Peninsular Japan, using bed by bed correlation of intercalating almost over 200 pyroclastic key beds (as described "tuff"), to investigate formative mechanism of folding structures during Plio- Pleistocene age.

ACRG found out the chaotic deposit caused by huge submarine landslide anomaly (HSLA) intercalated in normal marine deposits. The summarized characteristics of HSLA are ,

1. Distribution characteristics of HSLA can be traced about 5 km laterally in strike direction.
2. HSLA is composed of two main characteristic parts, the chaotic slump deposits part of maximum 40 meter thickness, and non-deposition part with erosional surface due to slope failure, very resemble to unconformable contact which overlaying normal marine deposit.
3. HSLA deposition and erosional part are never distributed in northern folded area with slightly very fine sand weak intercalation, absent part estimated at least 2 meter distance with thickness.
4. Both two characters are overlaid by a same key bed (HF tuff-horizon: elder than Olduvai Event) all over the area.
5. The composition of HSLA deposits are almost block and clast approximately 60~70%, matrix composes of poor sorting pumiceous sand with shelly fragments. Many of HSLA successions are dominated in clast (grain) supported huge size blocks connected each other likely to bedded mudstone or faulted mudstone, to make difficult to identify normal deposit or abnormal one.
6. Many of tuffs HK, ME, ZR ....(tuff name) included in chaotic slump materials and blocks of HSLA can be correlated with those of normal original stratigraphic position can be identified, and approximately each block composition indicates overlaying by lower derives (ZR, ME...) on upper derives (HK...). HSLA might occurred in surface part at first, and gradually exposed more deep position slide as a result of slump deposit has formed.
7. Inferred from the stratigraphic sequence, original layer involved in HSLA is estimated about over 300 meter in thickness. The key bed SD is found in chaotic slump block, and other erosion dominated part, the SD is located immediately below KI is only preserved.
8. Surface distributed most eastern part is huge volume of slump material derives, which maximum eroded part remained E-W trend valley fill deposit after HF tuff deposited age.
9. HSLA was transported from north to south along the paleo-submarine slope controlled by geological settings, such as subsidence and uplifting which are partly indicated in paleo-current directions of turbidite intercalations.

Our ACRG don't have any discussion about trigger force to start landslide, but whole HSLA seems not to be associated with earthquake induced liquefied flow of surface sediments, because sliding body masses are very thick and consolidated almost solid character, which preserve intercalated identified key bed any characters, color, grain size, grain mineral composition and stratified marker.

Microfacies of the latest Jurassic–earliest Cretaceous limestones in the Kaminnyi Potik Unit (Ukrainian Carpathians) – reconstruction of a carbonate platform within a volcanogenic sequence

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In the frontal region of the Marmarosh Massif in the Ukrainian Carpathians the Outer Dacides-Severinides are represented by the Kaminnyi Potik and Rachiv units (nappes). The Kaminnyi Potik Unit is the most internal and structurally highest unit of the Fore-Marmarosh units and in many places is directly covered by the Marmarosh nappes of the Central East Carpathians (Marmarosh Massif). In the Ukrainian Carpathians the Kaminnyi Potik Unit occurs from the vicinity of Rachiv city to the Chyvchynian Mountains (on the Ukrainian-Romanian border zone). The volcano-sedimentary complex of this unit consists of the Upper Jurassic Chyvchyn Formation (up to 1000 m in thickness) and the Tithonian-Valanginian Kaminnyi Potik Formation (thickness 200 m). Both of these formations are represented by trachyandesites (basalts?), that are locally developed as pillow lavas, and volcano-sedimentary breccias with blocks of limestones, trachyandesites (basalts?), small fragments of red radiolarites within a volcanic/tuffitic matrix, coral limestones with basalt fragments and pyroclastic intercalations and thin-bedded micritic limestones with cherts interbedded with coarse/fine-grained calcareous and pyroclastic flysch turbidites. In the stratotype of the unit (Kaminnyi Potik section) we found biodetritic limestones containing abundant corals, bryozoans and crinoids, with subordinate benthic fauna including bivalves and foraminifers. These limestones are overlain by carbonate turbidites with several pyroclastic layers. In the Chyvchyn Mount section a thick debris flow also contains large blocks of coral limestones (up to 6 m in diameter).

Microfacies analysis documented a wide spectrum of carbonate sedimentation from a carbonate platform to a deep basin. These are represented by: oolitic-echinoderm packstones/grainstones, coral bioclasts, authigenic quartz packstones/grainstones, oolitic-lithoclast wackestones/packstones, lithoclast-echinoderm packstones, lithoclasts of packstone and radiolaria-echinoderm wackestones, radiolaria wackestones, radiolaria-calpionella wackestones and mudstones. Additionally, pyroclastic volcanic material is present either between grains or in the matrix. Occurrence of flow structures, graded beds and the range of lithoclasts indicate that the material was formed in shallower zones prior to downslope transport and deposition in deeper areas of the basin as carbonate-flysch deposits. We infer the carbonate lithologies to represent short-lived coral reef atolls as a part of a small but locally-differentiated carbonate platforms which surrounded active volcanoes during latest Jurassic/earliest Cretaceous times of the Outer Dacide-Severinide part of the Carpathian basins.

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