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The long term tsunami impact: Evolution of iron speciation and major elements concentration in tsunami deposits from Thailand

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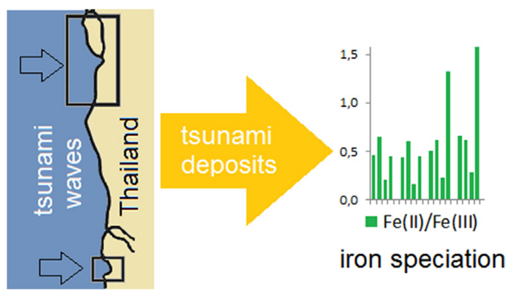
HIGHLIGHTS

- The evolution of the chemical composition of tsunami deposits has been observed.
- The spatial and temporal differentiation of iron speciation has been noticed.
- The results may be a reference point for future studies.

GRAPHICAL ABSTRACT



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ABSTRACT

The article describes the unique studies of the chemical composition changes of new geological object (tsunami deposits in south Thailand – Andaman Sea Coast) during four years (2005–2008) from the beginning of formation of it (deposition of tsunami transported material, 26 December 2004). The chemical composition of the acid leachable fraction of the tsunami deposits has been studied in the scope of concentration macrocompounds – concentration of calcium, magnesium, iron, manganese and iron speciation – the occurrence of Fe(II), Fe(III) and non-ionic iron species described as complexed iron (Fe complex). The changes of chemical composition and iron speciation in the acid leachable fraction of tsunami deposits have been observed with not clear tendencies of changes direction. For iron speciation changes the transformation of the Fe complex to Fe(III) has been recorded with no significant changes of the level of Fe(II).

1. Introduction

Tsunami is a natural phenomenon generated by earthquakes, landslides or volcano eruption.

Tsunami waves move through the ocean with a speed about a few hundred km per hour and while approach the coastline they rise to a height over 10 m and inundate even on the distance over 1 km in land. The earthquake which took place off the coast of Sumatra on the 26 December 2004 caused one of the biggest tsunamis in recorded history (Hussain et al., 2010; Lay et al., 2005; Szczuciński et al., 2005). Tsunami waves covered the coasts of Indonesia, Thailand, Sri Lanka, India, and other countries around the Indian Ocean and caused the death of 230 000 people both citizens and tourists. Hit with great energy tsunami pull down

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many buildings and flood hundreds of hectares of land covered the ground with tons of deposits - mostly in the form of sands and silts of marine origin (Szczuciński et al., 2006). While covered the former soil deposited sediments became a new component of land ecosystems being a subsoil for a new developing plants (Jonathan et al., 2012). It is very important because macro- and microelement are releasing to the environment by rain water and became a nutrient for these plants. Previous studies on the tsunami deposits have pointed to the high content of "salts", as well as the presence of heavy metals in bio-available (Srinivasalu et al., 2008; Szczuciński et al., 2007) and organomercury fractions of deposits (Boszke et al., 2006). The high occurrence of exchangeable fraction of arsenic were also found in the tsunami deposits in Thailand (Kozak and Niedzielski, 2013).

The geochemical markers evaluation for identification of the source of sediments seems to be an important part of geochemical studies (Krishnappan et al., 2009). The high content of iron at its low mobility and low biological significance occurring in sediments and soil has limited the studies of iron content (Bortleson, 1974). However, the use the information about the speciation of the elements in the monitoring of migration of the sediment (Kozak et al., 2013) or determining their origin [geochemical "fingerprint" (Barringer et al., 2011; Mayr et al., 2009)] may generate the interest in iron speciation studies (Qi-xing et al., 2003).

26 December 2004 tsunami in Thailand covered the large area [about 20,300 ha, in many places the tsunami waves reached up to 1.5 km inland (UNEP, 2005)] with the layer of sediments with thickness was from few to several tens centimetres [the average thickness was about 8 cm (based on 98 measurements in 13 transects) and the maximum reached 52 cm (Szczuciński et al., 2006)] and tsunami sediments deposited on land were the source of contaminations (Szczuciński et al., 2005, 2007). The present works have been focused on iron speciation studies [Fe(II), Fe(III) and non-ionic iron (described as Fe complex) determination] and the major elements: calcium, magnesium, iron, manganese determination in the acid leachable fraction (Jonathan et al., 2010) of tsunami deposits from Thailand.

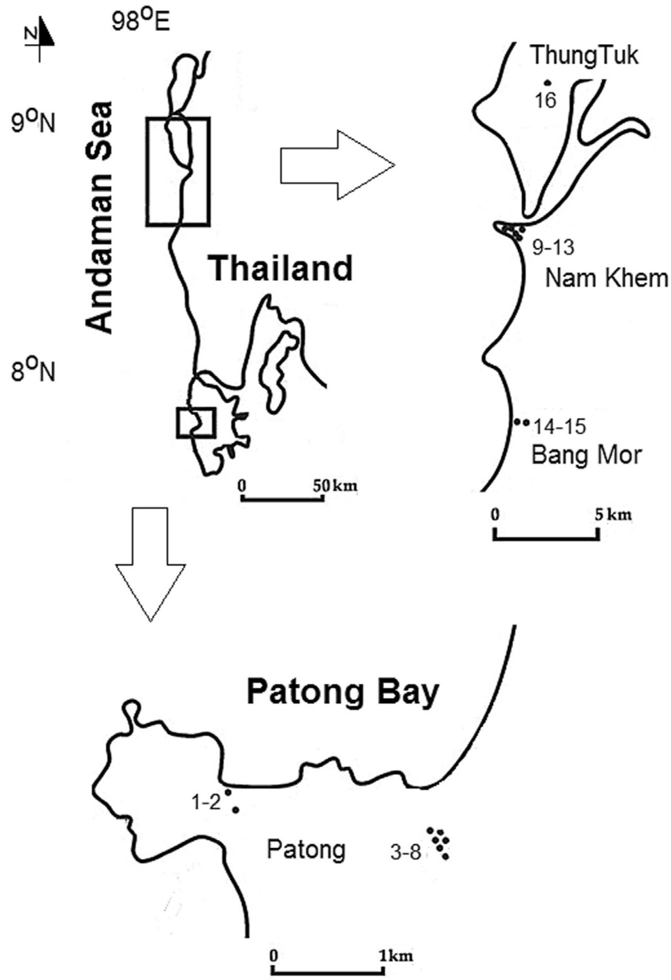

Fig. 1. The area of the studies.

2. Experimental

2.1. Sampling of tsunami deposits

15 samples of the tsunami deposits (No. 1-15 Patong Beach, Phuket; Nam Khem and Bang Mor) the reference sample (No. 16) from the area outside the tsunami range (Thung Tuk, Kho Khao Island) have been obtained year by year by four field expeditions (2006–2008) in tsunami affected area in south Thailand (Fig. 1). Sampling points have been marked by the Global Positioning System and were described in details (location, latitude, longitude, thickness of tsunami deposits layer, distance from shoreline) in the previous work (Szczuciński et al., 2005). The entire tsunami deposits layer has been collected unless it was thicker than 5 cm. Otherwise, only the uppermost 5 cm thick layer has been sampled. Sampling has been provided by the plastic tools, in field samples have been irradiated by UV radiation to brake potential microbiologically caused changes of sample chemical composition and speciation. In laboratory samples have been dried by lyophilisation, homogenised by melting a sieving by the 0.02 mm sieve. After drying samples have been stored frozen at ca −20 °C.

2.2. Sample preparation and analysis

Extraction of the acid leachable fraction of samples has been provided by hydrochloric acid follow the procedure prepared before (Kozak and Niedzielski, 2013). 2.00 g of sample has been extracted by 20 mL of 2 mol L^{-1} hydrochloric acid in the temperature 80 °C under reflux. After extraction solution was filtered and, if necessary, diluted by water to a final volume 20.0 mL. The solution has been used both for iron speciation studies and Ca, Mg, Fe, Mn determination in acid leachable fraction of the deposits. The procedure of iron speciation studies has been described in details in previous work (Kozak et al., 2013). For determination iron ionic forms: Fe(II), Fe(III) and iron in not ionic form e.eg. complexed iron, the tandem flow injection system with two detectors: diode array spectrophotometry and flame atomic absorption spectrometry has been constructed. The concentration of Fe(II) and the sum of concentration Fe(II) and Fe(III) has been determined by spectrophotometry after reaction of Fe(II) and Fe(III) with 1.10-phenanthroline simultaneously at 512 nm and 396 nm respectively, the total iron concentration has been determined by flame atomic absorption spectrometry at 248.3 nm. Additionally, the occurrence of magnesium, calcium and manganese has been determined by atomic absorption spectrometry with flame atomization. For selected samples the colourimetric determination of Fe(II) with 2.2'-dipirydile and Fe(III) with potassium sulphocyanate has been provided follow previously described methodology (Niedzielski et al., 2014).

2.3. Instruments and reagents

The flow injection system consisted of an LC-10AT chromatographic pump (Shimadzu, Japan) and an injection valve Rheodyne