Tephra from the Pleistocene loess deposits of the Island of Susak (northern Adriatic, Croatia) - problems with characterization

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Island of Susak, in the Kvarner archipelago, covers an area of 3.8 km^2 with the highest peak at 96 m above sea level. It's almost horizontal Cretaceous limestone basement is covered with up to 90 m thick loess and loess-like sediments intercalated by sandy layers, palaeosols, carbonate concretions and at least three tephra layers (first introduced by BOGNAR et al., 2002). This study provides data on mineralogical and geochemical properties of tephras as well as deposition ages based on stratigraphically important loess horizons. The emphasis is on the problems of geochemical characterization of tephra and determination of possible volcanic sources.

Heavy minerals (32 to 125 μm size fraction), separated using bromoform after removal of carbonate, were studied by polarizing microscope. Bulk-rock chemical analyses were carried out in ACME Analytical Laboratories Ltd., Vancouver (Canada). Analysis of vitroclasts was performed by SEM-EDS. The ages were obtained by Infrared stimulated luminescence (IRSL) dating method.

The oldest (TF1) and the youngest (TF3) tephra are situated in loess while middle tephra (TF2) is patchy distributed in brown palaeosol (Fig). First IRSL dating showed that loess-palaeosol sequence including upper two tephra layers correlates to Oxygen Isotope Stage 3 (WACHA et al., in press). Based on more recent IRSL dating of loess sandwiching the tephra, the TF3 from Bok section is between 29.9 ± 2.2 and 31.0 ± 2.3 ka old and between 28.0 ± 2.1 and 28.8 ± 2.1 ka old in Sand pit section. TF2 is between 39.0 ± 3.3 and 41.2 ± 3.6 ka old and TF1 is between 93.3 ± 7.0 and 98.3 ± 7.3 ka old.

Although all tephras have similar main and heavy mineral composition as loess (MIKULČIĆ PAVLAKOVIĆ et al., in press), the main characteristics are vitroclasts, rare idiomorphic biotite, and higher pyroxene content (serrated clinopyroxene in TF1 and idiomorphic, green augite in TF2 and TF3). Similar vitroclast morphology in TF1 and TF3 points to the same type of volcanism, whereas TF2 is a bit different not only by elongated and tubular vitroclasts which could be indicative for a strong eruption of Plinian-type, but also by its geochemical characteristics. Serration of oldest tephra clinopyroxenes could be a result of diagenesis in the lower (the oldest) unit of the loess sequence.

Bulk-rock chemistry shows minor differences between TF2 and other two, but according to TAS diagram all have intermediate composition with low alkali content (Na and K). Chemical composition of the vitroclasts differs from the bulk-rock chemistry mostly by lower alkali content which could be a consequence of weathering and difficulties in the detection of light elements (especially Na). Geochemical characterization could be influenced by pedogenesis and weathering (depletion of alkalies) as well as by mixing of volcanic material with loess (higher SiO_2 content).

Based on the age, mineral association, morphology of volcanic particles and similarities with other tephra layers (Marche province, CHIESA et al., 1990; Paglicci Cave, Italy, CREMASCHI & FERRARO, 2007), middle tephra from Susak could be related to Campanian Ignimbrite eruption of the Phlegraean Fields dated around 39 ka (DE VIVO et al., 2001). Considering the age of TF1 and TF3 and the similarities of idiomorphic and serrated augite in other regions such as Aeolian arc (GARZANTI & ANDÒ, 2007), Island of Hvar in Central Dalmatian archipelago (LUŽAR-OBERITER et al., 2007) and Campanian province (PECCERILLO, 2005), those tephras could be related to the Middle and South Italian volcanic provinces. Due to abundance and frequency of Italian volcanic activity during Pleistocene (PECCERILLO, 2005) the additional analyses are required for further characterization of Susak's tephra horizons and correlation with possible sources of this volcanic material.

REFERENCES:

BOGNAR, A., SCHWEITZER, F. & KIS, E. (2002): The Reconstruction of the Paleoenvironmental History of the Northern Adriatic Region Using of the Granulometric Properties of Loess Deposits on Susak Island, Croatia.-Chikei:Transactions-Japanese Geomorphological Union, 23/5, 795-810.

CHIESA, S., COLTORTI, M., CREMASCHI, M., FERRARIS, M., FLORIS, B. & PROSPERI, L. (1990): Loess sedimentation and quaternary deposits in the Marche province.-In: CREMASCHI, M. (ed.): The loess in northern and central Italy: a loess basin between the Alps and the Mediterranean region. Guide-book to the excursion in Northern and Central Italy, INQUA Commission on Loess, C.N.R. Quaderni di Geodinamica Alpina e Quaternaria, 1, Milano, 103-130.

CREMASCHI, M. & FERRARO, F. (2007): The Upper Pleistocene in the Paglicci Cave (Gargano, Southern Italy): Loess and tephra in the anthropogenic sequence.-Atti della Societa Toscana di Scienze Naturali, Memorie, Serie A, 112, 153-163.

DE VIVO, B., ROLANDI, G., GANS, P.B., CALVERT, A., BOHRSON, W.A., SPERA, F.J. & BELKIN, H.E. (2001): New constraints on the pyroclastic eruptive history of the Campanian volcanic Plain (Italy).-Mineralogy and Petrology, 73, 47-65.

GARZANTI, E. & ANDÒ, S. (2007): Plate tectonics and heavy mineral suites of modern sands.-In: MANGE, M.A., WRIGHT, D.T. (eds.): Heavy minerals in use. Developments in Sedimentology, Elsevier, 58, 741-763.

LUŽAR-OBERITER, B., BABIĆ, Lj. & CRNJAKOVIĆ, M. (2007): Sources of modern beach sands from two islands in the eastern Adriatic (Croatia).-In: Book of Abstracts Patras: International Association of Sedimentologists, 268 pp.

MIKULČIĆ PAVLAKOVIĆ, S., CRNJAKOVIĆ, M., TIBLJAŠ, D., ŠOUFEK, M., WACHA, L., FRECHEN, M. & LACKOVIĆ, D. (in press): Mineralogical and Geochemical Characteristics of Quaternary Sediments from the Island of Susak (Northern Adriatic, Croatia).-Quaternary International, doi:10.1016/j.quaint.2010.02.005.

PECCERILLO, A. (2005): Plio-Quaternary Volcanism in Italy-Petrology, Geochemistry, Geodynamics.-Springer, Berlin, 365 p.

WACHA, L., MIKULČIĆ PAVLAKOVIĆ, S., NOVOTHNY Á., CRNJAKOVIĆ, M. & FRECHEN, M. (in press): Luminescence Dating of Upper Pleistocene Loess from the Island of Susak in Croatia.-Quaternary International, doi:10.1016/j.quaint.2009.12.017.

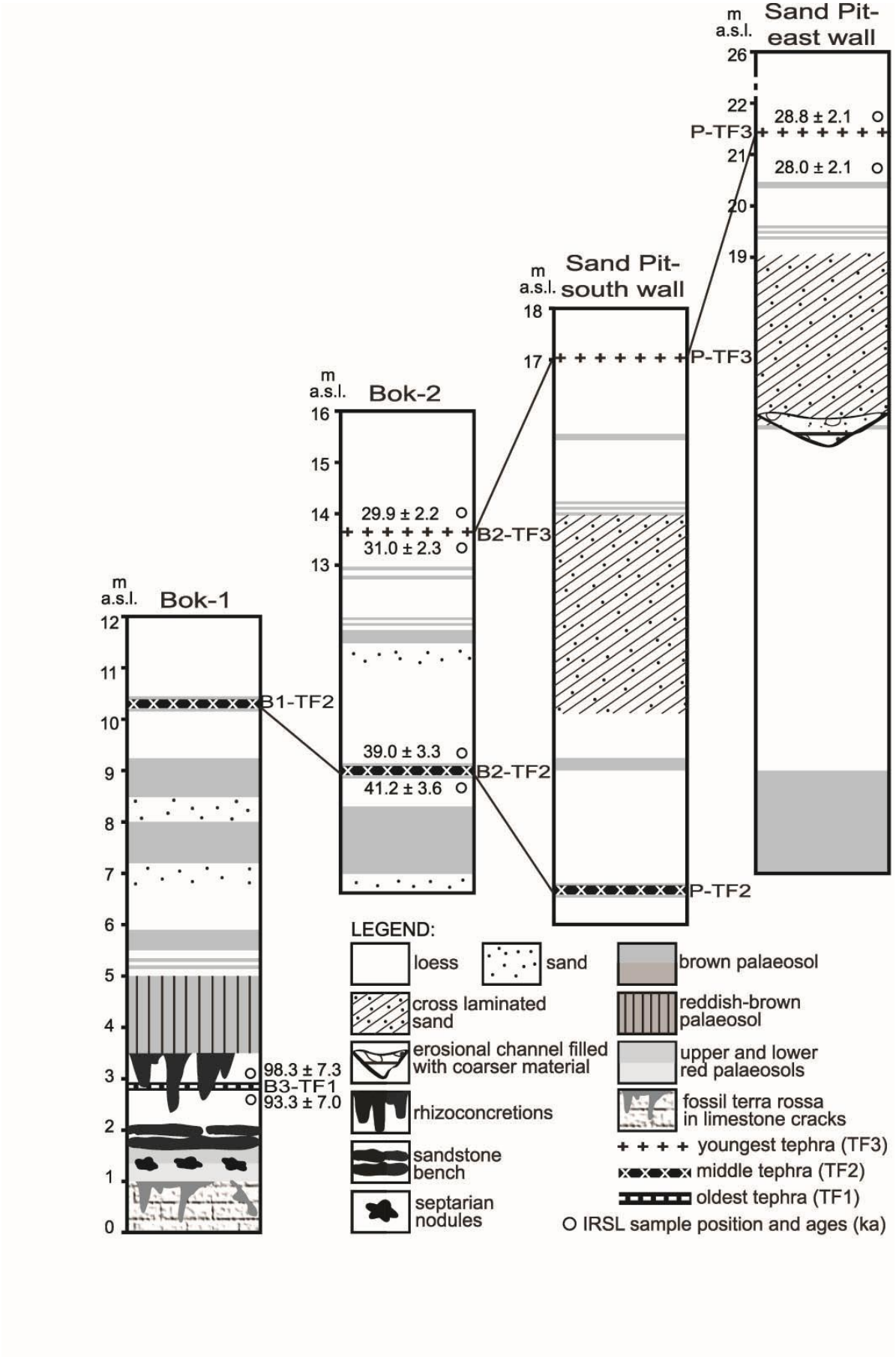

Figure: Stratigraphic sequences of Susak loess sections at Bok Bay (Bok-1, Bok-2) and Susak's sand pit (Sand Pit-south wall, Sand Pit-east wall) with indicated IRSL dating results