Research Networking Programmes

Short visit grant ☐ or exchange visit grant ☒

(please tick the relevant box)

Scientific report

The scientific report (WORD or PDF file - maximum of eight A4 pages) should be submitted online within one month of the event. It will be published on the ESF website.

Proposal Title: **Stratigraphic and paleoenvironmental analysis of the Holocene transgressive deposits in the northern Adriatic Sea**

Application Reference N°: 4870

1. Purpose of the visit

The main purpose of this visit was to work on a project that concerns the stratigraphy and palaeoecology of the Holocene transgressive deposits in the northern Adriatic Sea. This multidisciplinary project is aimed to quantify the magnitude and timing of the postglacial sea level rise by analyzing the Holocene shallow marine transgressive deposits and to reconstruct the ecological history of the northern Adriatic related with the human activities in the sediment source area. It includes sedimentological and geochemical analyses (grain size, TOC, trace metals, carbonate content), palaeontological and micropalaeontological analyses (molluscs and benthic foraminifera) and dating of sediments and shells using radiometric ^{210}Pb dating and the ^{14}C calibrated amino-acid-racemisation method (AAR). The majority of these analyses are currently being carried out within the FWF project "Historical ecology of the Northern Adriatic Sea", under leadership of Prof. Dr. Martin Zuschin.

The main purpose of my visit and my role within this project was to work on the environmental evaluation using benthic foraminiferal assemblages and their down-core changes that may be related to postglacial sea level rise, to integrate this data with the results from all other analyses and finally to help in establishing the chronology of the sedimentation in the northern Adriatic. During this five months period, my primarily task was to pick, sort and identify the species under a binocular microscope, but also to carry out statistical analyses and the interpretation of the data.

2. Description of the work carried out during the visit

The main work I carried out during my visit was to pick, sort and identify the species under a binocular microscope and it took the majority of my time, because of the nature of the analysis itself (counting at least 300 individuals from each sample) and because of the very large number of the samples (7 cores, each core containing 38 samples, each sample divided into 4 fractions, making all together 1064 subsamples anticipated for the analyses). So far, we finished the analysis of one core (Brijuni islands), half of second core (Piran) and surface samples from the core in front of the River Po mouth, which makes all together approximately 270 samples. Furthermore, we devoted some time to statistical analyses, interpretation of the data, preparation for its presentation at the European Geoscience Union General Assembly in Vienna in April 2015 and for writing the first manuscript that we plan to submit for publishing by the end of July 2015.

3. Description of the main results obtained

Preliminary results presented here include initial data for all sampling stations: overview of the data for each studied higher taxon (number of individuals and number of species), core description, sedimentation rates and dating, but also more detailed description and interpretation of the results from the Brijuni Islands.

3.1. Sampling locations

The northern Adriatic features several zones with different sedimentological characteristics as well as gradients of nutrient content and sedimentation regimes. Such zones represent distinct habitats for benthic organisms. In 2013, at seven sampling stations located along the northern Adriatic, 1.5-m-deep sediment cores were taken by Prof. Martin Zuschin and his research team. This sampling campaign covered the main sediment types, as well as different nutrient and sediment conditions (Figure 1).

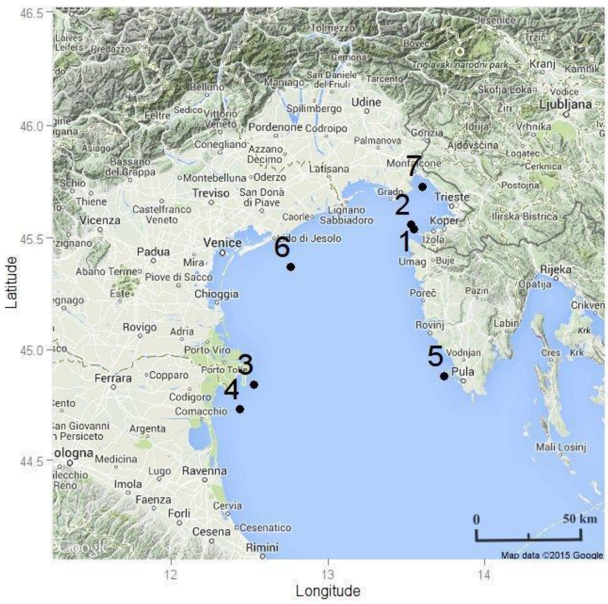

Figure 1. Map of the study area with sampling locations

3.2. Core descriptions, sedimentation rates and dating

Based on the site-specific sedimentation rates, ranging from 0.15 cm per year at the Brijuni Islands to 2.3 cm per year at the Po River Delta, and assuming that the sedimentation is constant over time, we calculated minimum ages for the cores that, accordingly, can cover from about 66 (Po Delta) to 1100 (Brijuni Islands) years of ecological history (Table 1). However, the calculated age most probably underestimates the real age of the core because episodes of resuspension, non-deposition and erosion are not considered. For example, at the Brijuni Islands, we found terrestrial sediments at the bottom of the core, which point to a much larger time span covered. Dating of shells (work in progress) will enable better estimates.

Table 1. Water depth of stations along with core diameters, core lengths, sedimentation rates and extrapolated minimal ages (*work in progress)

	Water depth (m)	Core diameter (cm)	Core length (cm)	Sed. rate (cm/y)	Min. age (y)
St. 1. Piran I	22.7	1.60	152	0.15	963
St. 2. Piran II	21.8	0.90	144	0.25	559
St. 3. Po III Delta	21	1.60	152	2.3	66
St. 4. Po IV Buoy	20.9	1.60	152	1.79	85
St. 5. Brijuni Isl.	44	0.90	160	0.14	1100
St. 6. Venice	20.9	1.60	152	*	*
St. 7. Panzano	12.5	1.60	150	0.23	628

3.3. Overview of the palaeontological data from the northern Adriatic

At the moment, several higher taxa are being analysed within the above-mentioned project "Historical ecology of the Northern Adriatic Sea": bivalves, gastropods, ostracods, and we have already started with the analysis of foraminifera. As this is work in progress, the table is still incomplete, but it is being updated daily. Foraminifera are completed so far only for the station at Brijuni Islands, but preliminary data are shown also for Piran and Po (Table 2).

Table 2. Number of species and individuals for each studied group (*work in progress)

	Bivalves		Gastropods		Foraminiera		Ostracods	
	Species	Indiv.	Species	Indiv.	Species	Indiv.	Species	Indiv.
St. 1. Piran I	76	14671	95		126*	16544*		
St. 2. Piran II	72	13117	87	9018				
St. 3. Po III Delta	27	849	14	183	101*	4020*		
St. 4. Po IV Buoy	30	910	21	363				
St. 5. Brijuni Isl.	69	12223	104	10929	264	57844	21	980
St. 6. Venice	65	5039						
St. 7. Panzano	40	3002						

3.4. Stratigraphic and paleoenvironmental analysis of the Holocene transgressive deposits from the Brijuni Islands

3.4.1. Radiometric dating of the Brijuni sediments

The sediment was radiometrically dated at the Low-Level Counting Labor Arsenal of the University of Natural Resources and Applied Life Sciences, Vienna, by using ^{210}Pb dating.

At a depth of 21 cm, an age of ~112 years was determined for the sediment core. This is roughly equivalent to a sedimentation rate of 1.2 mm/yr (Fig. 2). At the deep end of the core, terrestrial sediment was reached, which points to an age of 8000 to 10,000 years when the area was flooded in the Holocene. This suggests that sedimentation rates were low throughout the core and points to the occurrence of sediment resuspension and/or sedimentation gaps.

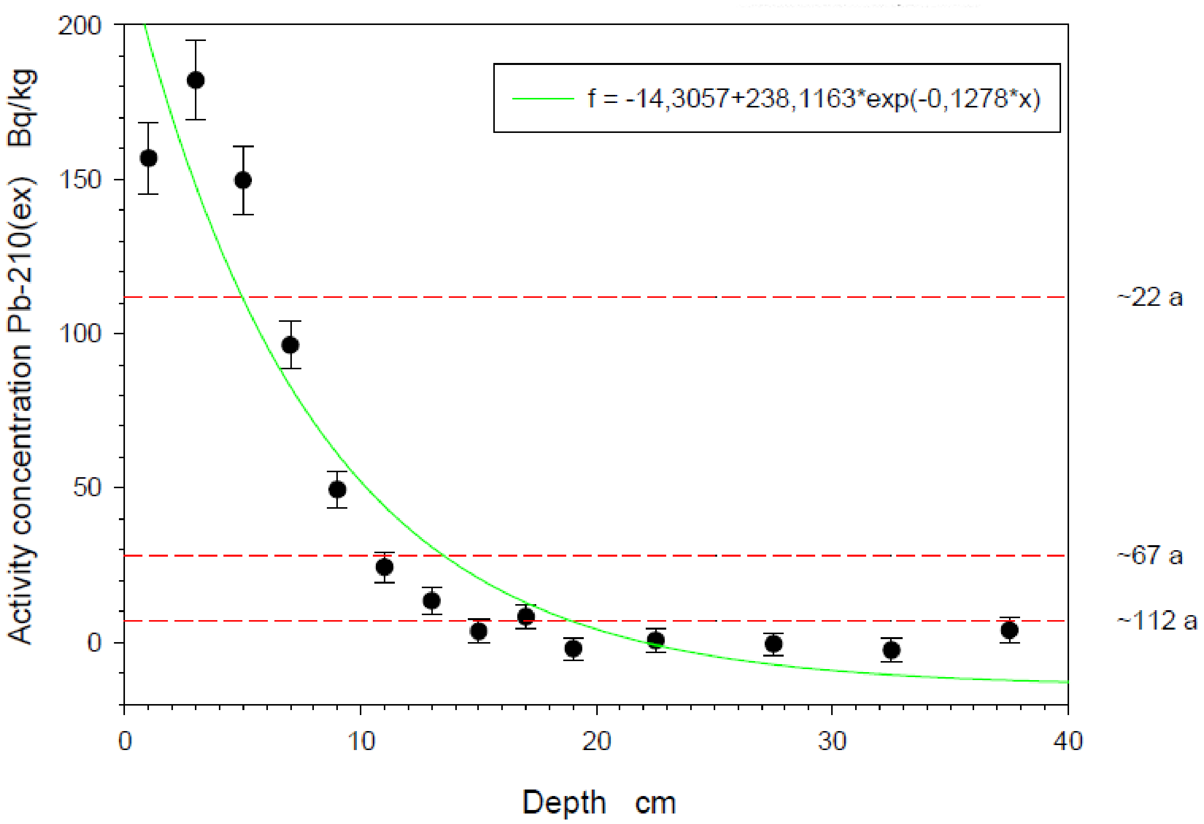

Figure 2. Radiometric dating of the sediments.

3.4.2. Foraminiferal assemblages in sediments from the Brijuni Islands

Standard properties of the foraminiferal assemblages (species richness, faunal composition, biodiversity indices) from sediments near the Brijuni Islands are analyzed from four sediment fractions of each sample (63, 125, 250 and 500 μm) and compared with relevant physical and geochemical properties of the sediment. Results from the 125 μm fraction, which comprises the majority of foraminiferal species found in the sediment and therefore is the most suitable for palaeoecological analyses, are shown here.

The innovative aspect of this methodological approach is that we will be able to test the suitability of each sediment fraction for monitoring ecological changes and compare it with total assemblages (> 63 μm), which are commonly used in palaeoecological studies.

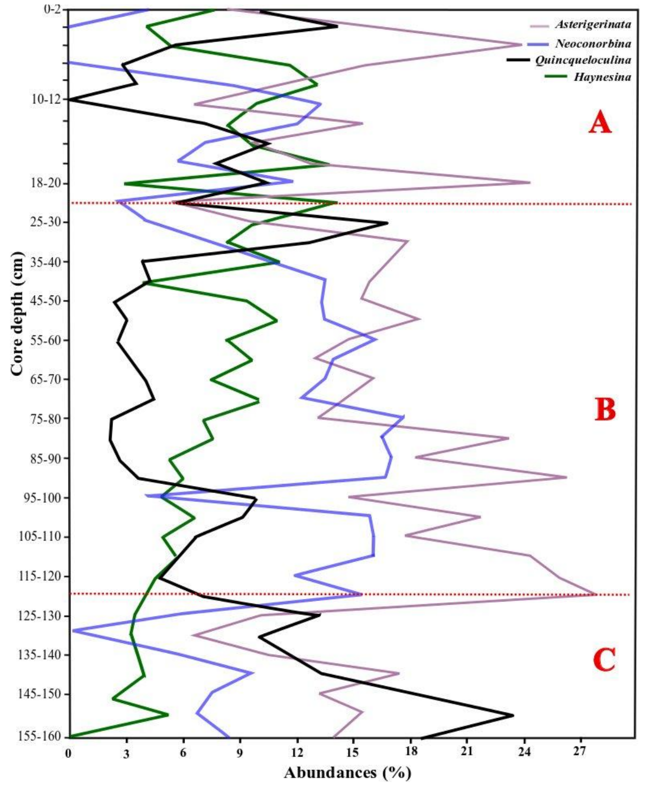

Figure 3. Down-core changes of selected foraminiferal genera: *Neoconorbina*, *Quinqueloculina*, *Asterigerinata* and *Haynesina*. Numbers A, B and C indicate the depth distribution of clusters resulting from cluster analysis (see Figure 4).

Genera that dominate the assemblage in sediments near the Brijuni Islands are: *Textularia*, *Quinqueloculina*, *Adelosina*, *Triloculina, Cibicides, Lobatula, Planorbulina*, *Rosalina, Elphidium, Haynesina* and *Ammonia.* The majority of them show distinct distribution patterns along the core (Figure 3): the genus *Quinqueloculina* has a pronounced abundance decrease in the middle part of the core; the genera *Neoconorbina* and *Asterigerinata* have the opposite trend, while genus *Haynesina* shows a general decrease of its relative abundance downcore. Moreover, their maximum appearences as well as important and abrupt shifts in their abundances are used to define upper and lower limits of major asemblages (A–C) and therewith to supplement the grouping obtained by multivariate analyses (Figures 4 and 5).

Raw species richness in the first 20 cm is lower (18-42 species per sample) compared with the middle part of the core (39 to 53 species), and decreases again from 100 cm downwards (25 to 42 species). Diversity indices follow the pattern of species richness and point to normal marine conditions (Table 3). Changes in species richness and diversity indices can be attributed to changes in sedimentation rate, nutrient input, human activities such as bottom trawling and consequent resuspension of the sediment.

Table 3. Biodiversity indices for foraminiferal assemblages from the 125 μm fractions

	0-2	**2-4**	**4-6**	**6-8**	**8-10**	**10-12**	**12-14**	**14-16**	**16-18**	**18-20**	**20-25**	**25-30**	**30-35**
Taxa	31	23	41	24	26	18	19	26	42	31	38	42	34
Individuals	343	253	308	213	299	146	241	248	189	230	196	310	232
Dominance	0.05	0.09	0.06	0.08	0.06	0.08	0.08	0.05	0.06	0.06	0.07	0.04	0.05
Shannon	3.12	2.75	3.24	2.86	3.06	2.74	2.67	3.08	3.21	2.99	3.11	3.52	3.15
Evenness	0.73	0.68	0.62	0.73	0.82	0.86	0.76	0.83	0.59	0.64	0.59	0.81	0.69
Equitability	0.91	0.88	0.87	0.90	0.94	0.95	0.91	0.94	0.86	0.87	0.85	0.94	0.89
Fisher	8.27	6.15	12.70	6.95	6.84	5.40	4.84	7.32	16.74	9.65	14.05	13.10	10.98
	35-40	**40-45**	**45-50**	**50-55**	**55-60**	**60-65**	**65-70**	**70-75**	**75-80**	**80-85**	**85-90**	**90-95**	**95-100**
Taxa	53	46	51	45	48	45	39	50	44	43	49	40	45
Individuals	326	272	406	287	383	327	216	303	350	364	336	238	256
Dominance	0.06	0.06	0.06	0.06	0.07	0.06	0.06	0.05	0.07	0.09	0.07	0.11	0.04
Shannon	3.34	3.23	3.28	3.16	3.20	3.21	3.18	3.34	3.17	2.99	3.23	2.87	3.46
Evenness	0.53	0.55	0.52	0.52	0.51	0.55	0.61	0.56	0.54	0.46	0.52	0.44	0.71
Equitability	0.84	0.84	0.83	0.83	0.83	0.84	0.87	0.85	0.84	0.79	0.83	0.78	0.91
Fisher	17.95	15.87	15.42	14.98	14.50	14.13	13.90	17.05	13.30	12.68	15.79	13.76	15.83
A-E index	34.8	22	50	54.8	32.3	35.7	66.7	0	17.4	61.9	50	33.3	57.1
	100-105	**105-110**	**110-115**	**115-120**	**120-125**	**125-130**	**130-135**	**135-140**	**140-145**	**145-150**	**150-155**	**155-160**	
Taxa	37	30	38	32	27	42	27	47	38	37	38	25	
Individuals	247	151	352	288	299	260	299	391	405	300	305	217	
Dominance	0.07	0.10	0.09	0.12	0.06	0.05	0.06	0.04	0.06	0.04	0.05	0.06	
Shannon	3.05	2.86	2.99	2.73	2.98	3.29	2.98	3.57	3.19	3.38	3.29	3.01	
Evenness	0.57	0.58	0.53	0.48	0.73	0.64	0.73	0.75	0.64	0.80	0.70	0.81	
Equitability	0.85	0.84	0.82	0.79	0.91	0.88	0.91	0.93	0.88	0.94	0.90	0.94	
Fisher	12.06	11.24	10.82	9.21	7.20	14.18	7.20	13.96	10.27	11.10	11.45	7.30	

Cluster analyses of foraminiferal assemblages obtained from 125 μm sediment fractions reveal three groups of foraminiferal assemblages (distance level 8) and therewith supplement trends observed from downcore changes of foraminiferal species abundances (Figure 4):

(A) in the top 25 cm, with higher abundances of the genus *Haynesina*, low abundances of the genus *Neoconorbina,* two *Asterigerinata* peaks and lower biodiversity; the lower limit of the assemblage concides with minimum abundances of the genera *Quinqueloculina, Asterigerinata* and *Neoconorbina* and the beginning of the decrease of *Haynesina*;

(B) in the middle part of the core (25 to 125 cm) with high abundances of the genera *Asterigerinata* and *Neoconorbina*; the lower abundances of *Quinqueloculina* and higher biodiversity indices, the lower limit of this assemblage concides with the beginning of *Asterigerinata* and *Neoconorbina* decrease and *Quinqueloculina* increase;

(C) in the bottom of the core, with low abundances of *Haynesina, Asterigerinata* and *Neoconorbina,* increasing abundances of *Quinqueloculina* and lower biodiversity (Figures 4 and 5). These groups can be well recognized by a principal component analysis (Figure 5).

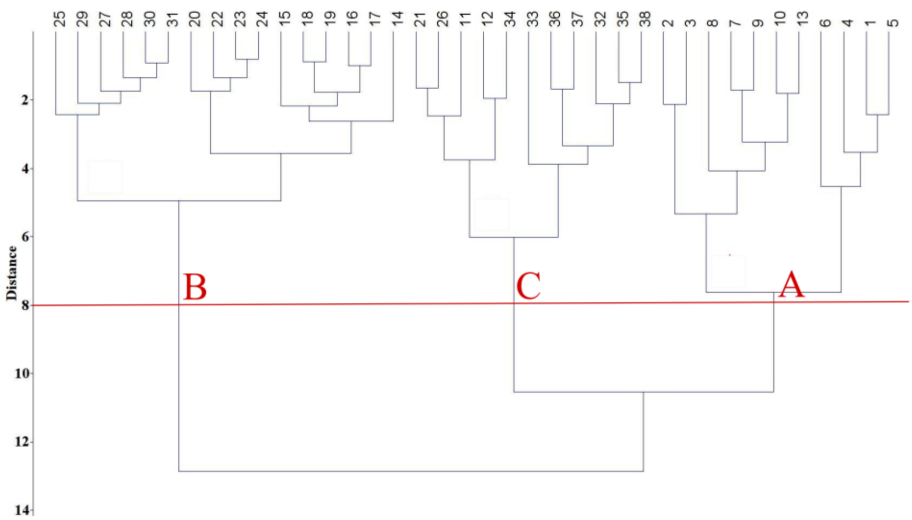

Figure 4. Dendrogram obtained by cluster analysis (Ward's method), using foraminiferal assemblages from the 125 μm fractions. Sediment depths are represented with numbers, starting from 1 (0-2 cm) to 38 (155-160 cm).

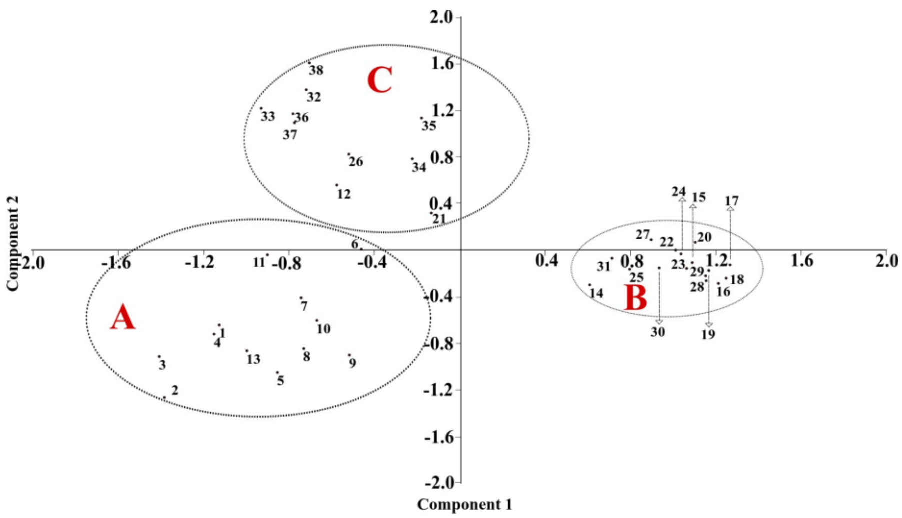

Figure 5. Ordination diagram obtained by principal component analysis, using foraminiferal assemblages from the 125 μm fractions. Sediment depths are represented with numbers, starting from 1 (0-2 cm) to 38 (155-160 cm).

3.4.3. Ecological history of the Brijuni Islands

Based on determined age of ~112 years at a depth of 21 cm, together with roughly estimated sedimentation rate of 1.2 mm/yr and assuming that the sedimentation is constant over time; minimum age that the Brijuni sediment core could cover is 1100 years of ecological history. However, terrestrial sediment at deep end of the core and high abundance of land and freshwater gastropods in the deepest samples point to an age of 8000 to 10,000 years when the area was flooded in the Holocene. Moreover, this suggests that sedimentation rates were low throughout the core and points to the occurrence of sediment resuspension and/or gaps in sedimentation near the Brijuni Islands. The gaps or periods of sediment reworking could partly explain the observed downcore changes in foraminiferal species composition and above described foraminiferal assemblages, but at the moment, without knowing the exact dates of the sediment, it is difficult to establish and explain the chronology of events near the Brijuni Islands. Dating of molluscs' shells will enable better estimates and more precise interpretation of ecological events in this part of the northern Adriatic.

4. Future collaboration with host institution

Our research is growing into the first broad-scale study of this type in the northern Adriatic, so we plan to continue with our collaboration. Also, we broadened our collaboration network with new research partner Dr. Sylvain Richoz from the Institute of Earth Sciences, University of Graz, Austria. Dr. Richoz will carry out the analyses of stable isotopes from foraminiferal tests. Furthermore, there are four students from the University of Vienna who will start in March working on their bachelor theses about benthic foraminiferal assemblages in the sediment cores from the northern Adriatic.

5. Projected publications / articles resulting or to result from the grant

Whilst preparing our first data for the presentation at EGU 2015, we will also be working on their complete description and detailed interpretation, which will be written as an article by the end of July, 2015. The reference of the abstract submitted to EGU 2015 is:
Vidović J, Ćosović V, Gallmetzer I, Haselmair A, Zuschin M (2015) Marine historical ecology at the Brijuni Islands, Croatia: preliminary results from down-core changes of foraminiferal assemblages.

6. Other comments

I am grateful to the European Science Foundation for providing me the opportunity to work at the Department of Palaeontology in Vienna. My visit at the Department of Palaeontology was one of my greatest working experiences. I had the opportunity to work in incentive and inspiring working atmosphere, to be a part of international and interdisciplinary team and even to establish some new research collaborations. Finally, I am sincerely honoured to be a member of respectable institution like the University of Vienna.