TEST SITES IN EUROPE FOR THE EVALUATION OF GROUND MOTION AMPLIFICATION: SITE RESPONSE OF THE GUBBIO BASIN (CENTRAL ITALY) USING WEAK MOTIONS RECORDED BY LINEAR SEISMIC ARRAYS

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Fig. 1 – Map of Italy showing the location of the town of Gubbio.

Introduction: The aim of this poster is to present preliminary results of an in-progress seismological experiment in the Gubbio basin (Central Italy, Figure 1). Recordings of past earthquakes collected in the Gubbio basin have shown a strong influence of local geology on the amplitude and duration of the ground motion [2]. This study, financed by the Italian Civil Defence (DPC-INGV Projects) for the high seismic risk of the area, aims at the evaluation of the site response by using linear seismic arrays. The analysis of the collected data set, together with the results obtained in a companion study (poster n° 1858 – P683A), will help in highlighting and quantifying the influence of the sediment thickness, bedrock topography and S-wave velocity structure on the amplification and duration of the strong ground motion.

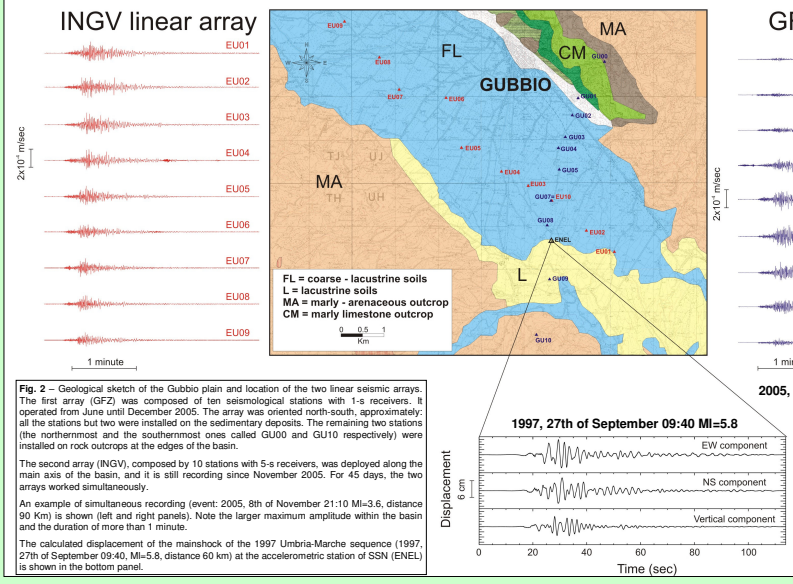

Fig. 2 – Geological sketch of the Gubbio plain and location of the two linear seismic arrays. The first array (GFZ) was composed of ten seismological stations with 1-s receivers. It operated from June until December 2005. The array was oriented north-south, approximately: all the stations but two were installed on the sedimentary deposits. The remaining two stations (the northernmost and the southernmost ones called GU00 and GU10 respectively) were installed on rock outcrops at the edges of the basin.

The second array (INGV), composed by 10 stations with 5-s receivers, was deployed along the main axis of the basin, and it is still recording since November 2005. For 45 days, the two arrays worked simultaneously.

An example of simultaneous recording (event: 2005, 8th of November 21:10 Ml=3.6, distance 90 Km) is shown (left and right panels). Note the larger maximum amplitude within the basin and the duration of more than 1 minute.

The calculated displacement of the mainshock of the 1997 Umbria-Marche sequence (1997, 27th of September 09:40, Ml=5.8, distance 60 km) at the accelerometric station of SSN (ENEL) is shown in the bottom panel.

Gubbio is a medieval town located in the Umbria district, central Italy (**Figure 1**). It was founded on a marly limestone outcrop, a typical stiff formation of northern Apennines (**Figure 2**).

The region is affected by moderate seismicity that did not produce severe damage in the past.

However, during the Umbria-Marche sequence in 1997, an accelerometric station of Servizio Sismico Nazionale (marked as ENEL in **Figure 2**) installed about 4 km south of Gubbio, recorded the mainshock. Displacements as large as 6 cm and duration more than 1 minute long were observed.

Because the Gubbio plain (northwest-southeast oriented, 4-km wide, 20-km long) is the expansion area of the town, and represents a typical basin structure in a seismic active area of Central Italy, it was one of the targets of Italian Civil Defense (DPC) projects, devoted to hazard mitigation in Italy.

With this aim, different kind of geophysical and geological investigation of the basin started within the framework of the DPC-INGV projects in 2005. In particular, the GeoForschungsZentrum Potsdam (GFZ) and the Istituto Nazionale di Geofisica e Vulcanologia of Rome (INGV) deployed two linear seismic arrays. **Figure 2** depicts one example of recordings at the array stations showing the strong amplification and longer signal duration at sites within the sedimentary basin.

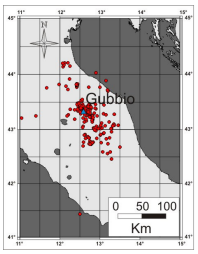

Fig. 3 – Epicentral map of the local earthquakes recorded by the two linear arrays from June to December 2005

From June to December 2005 the two linear arrays recorded more than 200 earthquakes (0.8≤M≤4.4). Most of them occurred less than 300 km away from Gubbio (**Figure 3**).

A data selection based on signal-to-noise ratio was carried out and the remaining data were analyzed in terms of conventional S-wave spectral ratios and horizontal-to-vertical spectral ratios (receiver functions or HVSR) (**Figure 4**). Both analyses show variations of site response moving from the stations installed on the stiff outcrops to those inside the basin.

HVSR spectral ratio results show that systematic low-frequency (0.3-0.4 Hz) amplification affects the stations in the middle of the basin. The resonance frequency peaks are consistent with the thickness and the average S-wave velocity of soft sediments derived from microtremor measurements in the basin (poster 1858 – P683A).

The conventional spectral ratio results (obtained using station GU00 as reference site) show a more complex broad-band (0.3-10Hz) amplification.

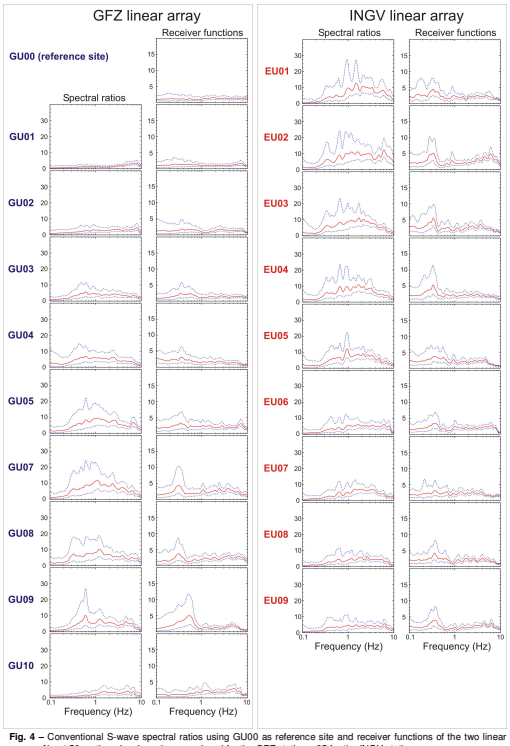

Fig. 4 – Conventional S-wave spectral ratios using GU00 as reference site and receiver functions of the two linear arrays. About 50 earthquakes have been analyzed for the GFZ stations, 25 for the INGV stations.

Differences between HVSR and spectral ratio results (occurring especially between 0.5 and 2 Hz) can be explained by the amplification of the vertical component. The sonogram analysis [3] of **Figure 5** shows that the vertical component is strongly amplified at the station within the basin especially in that frequency band. Such high level of the ground motion also lasts many seconds more than at the reference site GU00. Interestingly the amplification in this frequency band (higher than the estimated 1D resonance frequency of the sites) is related to secondary arrival that can be identified as surface waves by means of polarization analysis [1]. For the same earthquake of Figure 5 and for station GU08 (**Figure 6a**) , we calculated the instantaneous polarization attributes (**Figure 6b**). The ellipticity ratio varies from zero (linearly polarized arrival, colour blue) to one (elliptically polarized arrival, colour red). The planarity vector is defined as the vector perpendicular to the plane containing the particle motion. A value of this angle close to $\pi/2$ (colour red) means that most of the energy is incoming from the direction along the considered component.

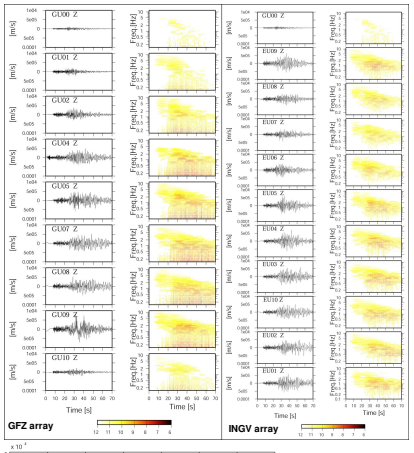

Fig. 5

Left-hand of each panel:

Vertical seismograms (event: 2005, 8th of November 21:10, Ml=3.6, distance 90 km) recorded by the two linear arrays. Seismograms are filtered in the 0.1-25 Hz frequency band.

Right-hand of each panel:

Comparison between vertical-component sonograms of the two linear arrays.

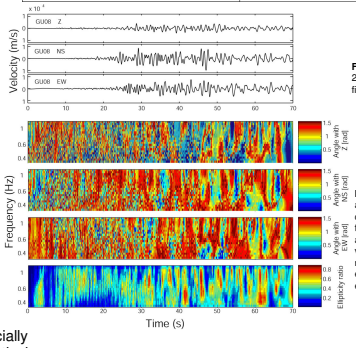

Figure 6a - Recordings at GU08 of the 2005, 8th November 21:10 earthquake filtered in the frequency band 0.2-4 Hz.

Figure 6b - Instantaneous polarization attributes [1] in the time-frequency domain of the event shown in Figure 6a. The first, the second, and the third panel show the angle between the planarity vector and the vertical, the NS and the EW directions, respectively. The bottom panel shows the ellipticity ratio (blue: linearly polarized; red: elliptically polarized arrival).

Conclusions:

A preliminary analysis of the collected data set confirmed the existence of significant 2D-3D effects in the Gubbio basin. These effects, previously observed mainly on strong motion data or simulations, are here triggered by small events and very weak motions. Future investigation will aim at quantifying 2D and 3D effects for hazard mitigation in sediment-filled intermediate depth plains.

References:

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