ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

Velocity profile report at the seismic station IV.BIOG – Camporeale-Ariano Irpino (AV)

Report sul profilo di velocità sismica per il sito della stazione sismica IV.BIOG – Camporeale-Ariano Irpino (AV)

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Subject: **Final report illustrating measurements, analysis and results for Vs profile at station IV-BIOG**	

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1. INTRODUCTION

In this report, we present the geophysical measurements and the results obtained in the framework of the 2019-2021 agreement between INGV and DPC, called *Allegato B2: Obiettivo 1 - TASK 2: Caratterizzazione siti accelerometrici (Responsabili: G. Cultrera, F. Pacor)* for the site characterization corresponding to Italian accelerometric stations. Here the results for station IV.BIOG (Camporeale-Ariano Irpino) are presented.

The collected geophysical measurements consist in four 2D arrays of different aperture and central position. The simultaneous acquisition of ambient vibrations provide results in terms of dispersion curves that are inverted to obtain shear-wave velocity (V_S) profiles for the studied area and suitable for assigning the soil class according to the current Italian seismic code [1] and the current Eurocode [2].

2. GEOPHYSICAL INVESTIGATIONS

Figure 1 shows the location of the stations used for the four 2D arrays, with the indications of aperture and distance between the central point and the position of station IV-BIOG (Latitude 41.19990 Longitude 15.13263 WGS84) inside the research center BioGeM (Biology and Molecular Genetics) of Ariano Irpino (AV).

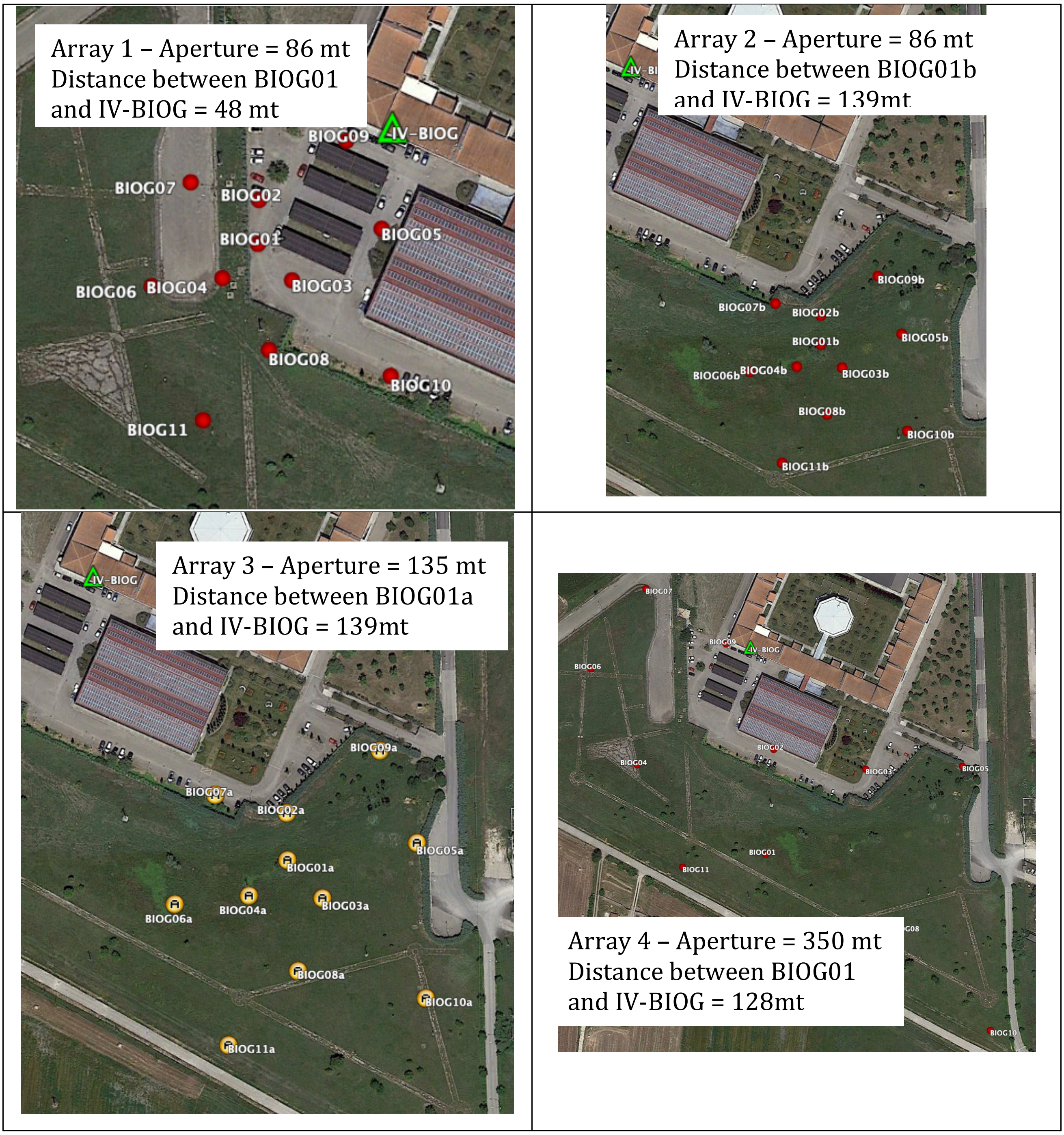

Figure 1: Map of Camporeale showing the four 2D arrays performed close to IV.BIOG station. We used eleven stations (red or yellow points) in passive configuration. All stations are equipped with Kinemetrics Q330 digitizer and Lennartz 3D-5sec velocimetric sensors. The green triangle indicates the station IV.BIOG.

All the arrays were performed using 11 single seismic stations equipped with Kinemetrics Q330 digitizers and Lennartz 3d-5s velocimetric sensors. The position of each station was accurately measured through a differential GPS system. From the total recordings we selected 2 hours for Array1, Array2 and Array3, and 3 hours for Array4. This preliminary selection was needed for avoiding the effects of unfavorable weather conditions during the recording periods.

The geometry controls the response of the arrays in terms of theoretical transfer function. In Figure 2 the array transfer functions for the four arrays are shown.

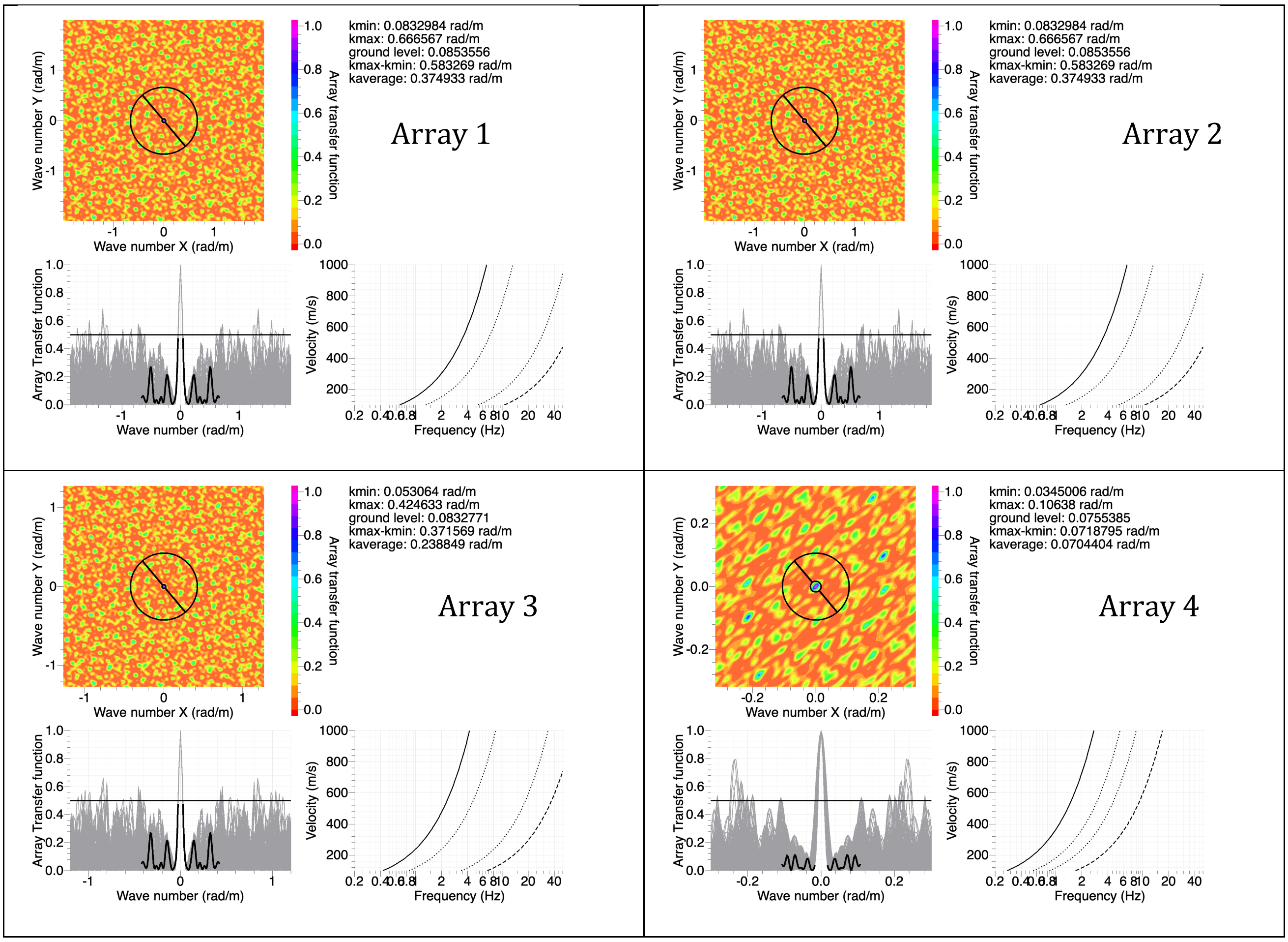

Figure 2: Array transfer functions (ATF) of the four arrays performed close to IV.BIOG station. Array 1 and 2 have the same configuration, then the ATF is the same.

Figure 3 shows the average H/V curves of the 11 stations recorded by each array.

The H/V curves of the four arrays are consistent below 1Hz, whereas there is a large variability for frequencies over 1Hz as an effect of anthropic and likely weather disturbances. Anyway, the spectra of vertical ground motions are much more similar, and then we use it to proceed with the FK analysis.

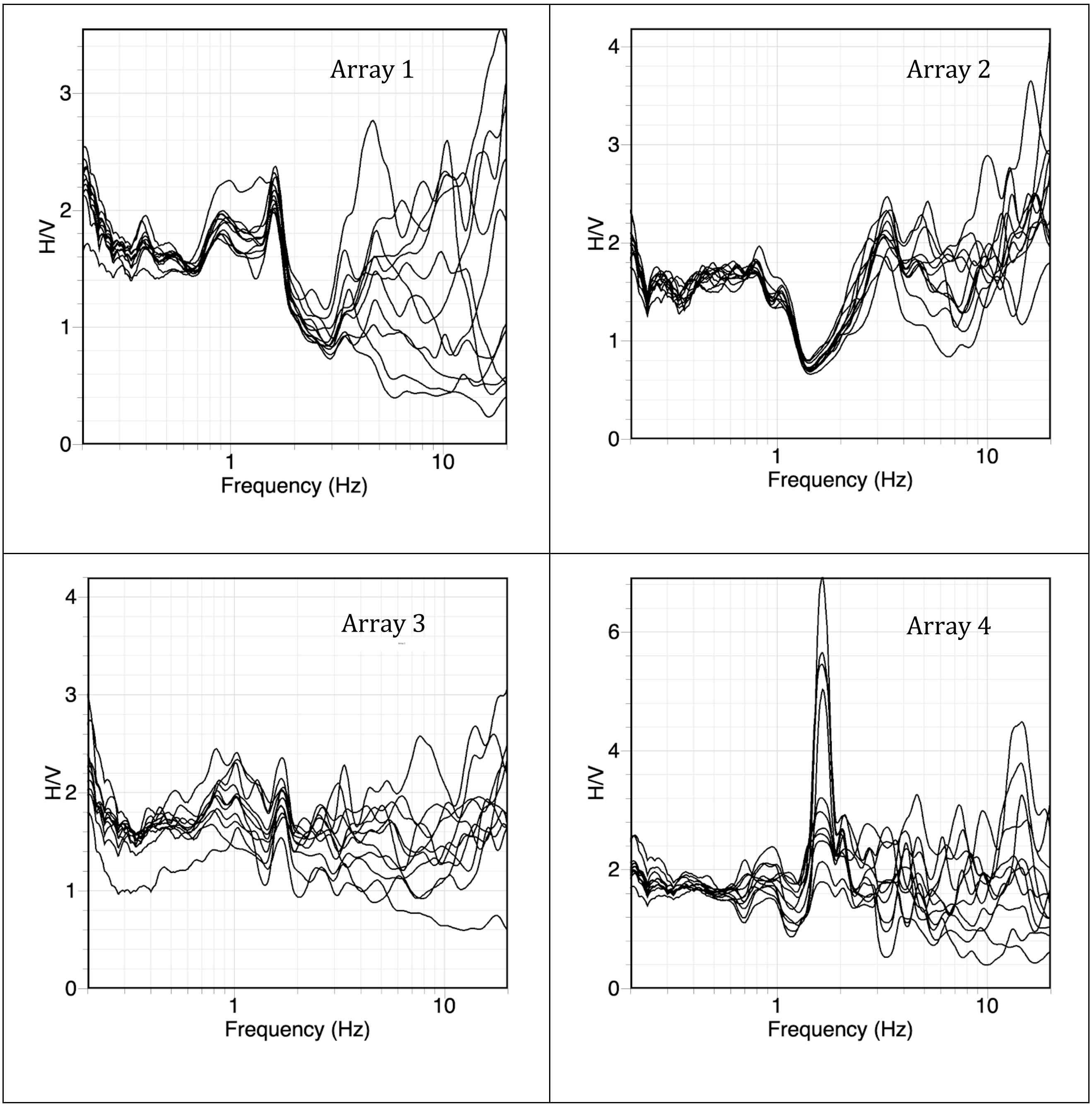

Figure 3: Average H/V curves of the stations of each array performed close to IV.BIOG station. Below 1Hz all the H/V curves are consistent each other, the shape is flat and the absolute amplitude is below 2.

Data from the four 2D arrays have been analysed in terms of FK techniques. Anyhow, only data of Array 2 and 3 allowed individuating a clear dispersion curve (Figure 4). The picked dispersion curves (fundamental mode) have been averaged and with the higher mode used as first target for the inversion (Figure 5). We interpret and assume that the final dispersion curve consists of the fundamental and the first higher mode of the Rayleigh dispersive waves.

For Array 3 we also applied the SPAC analysis with the aim to go to lower frequencies and calculate the reliable points of the autocorrelation curves and use them as target for the inversion (Figure 6).

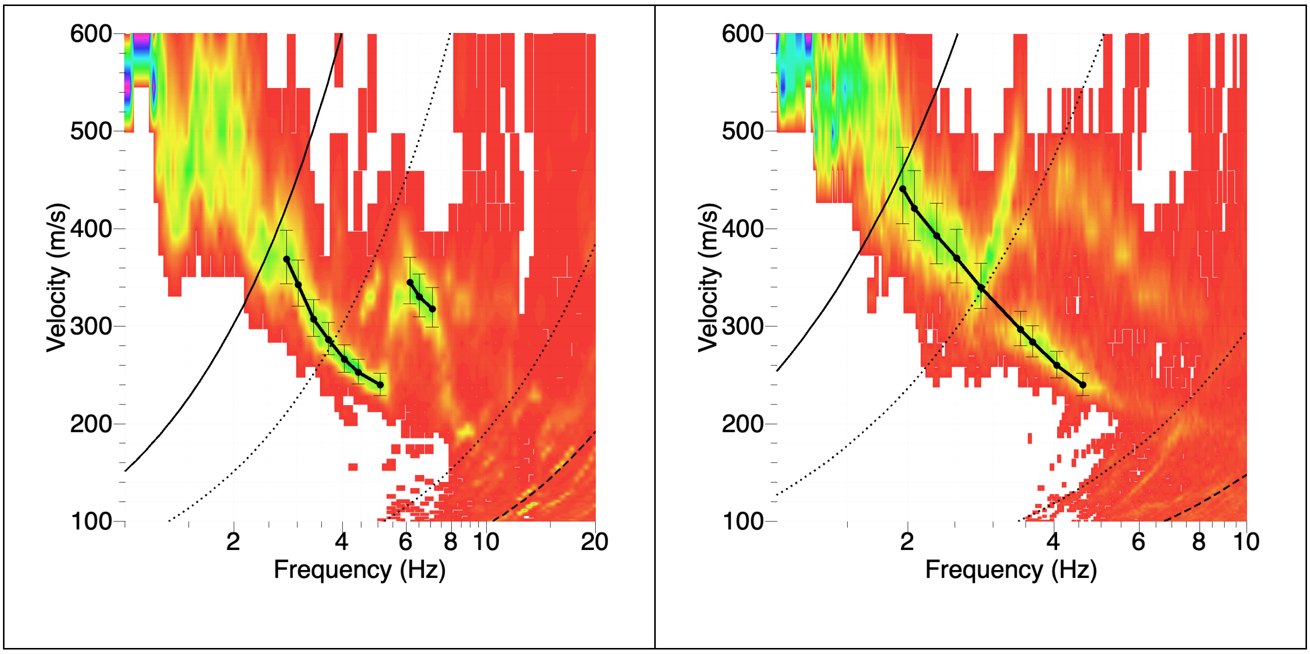

Figure 4: Dispersion curves carried out from FK analysis on data of Array 2 and 3. The geometric limits of the arrays are superimposed as well the picking of the curves. Note that for Array 2 a higher mode is visible.

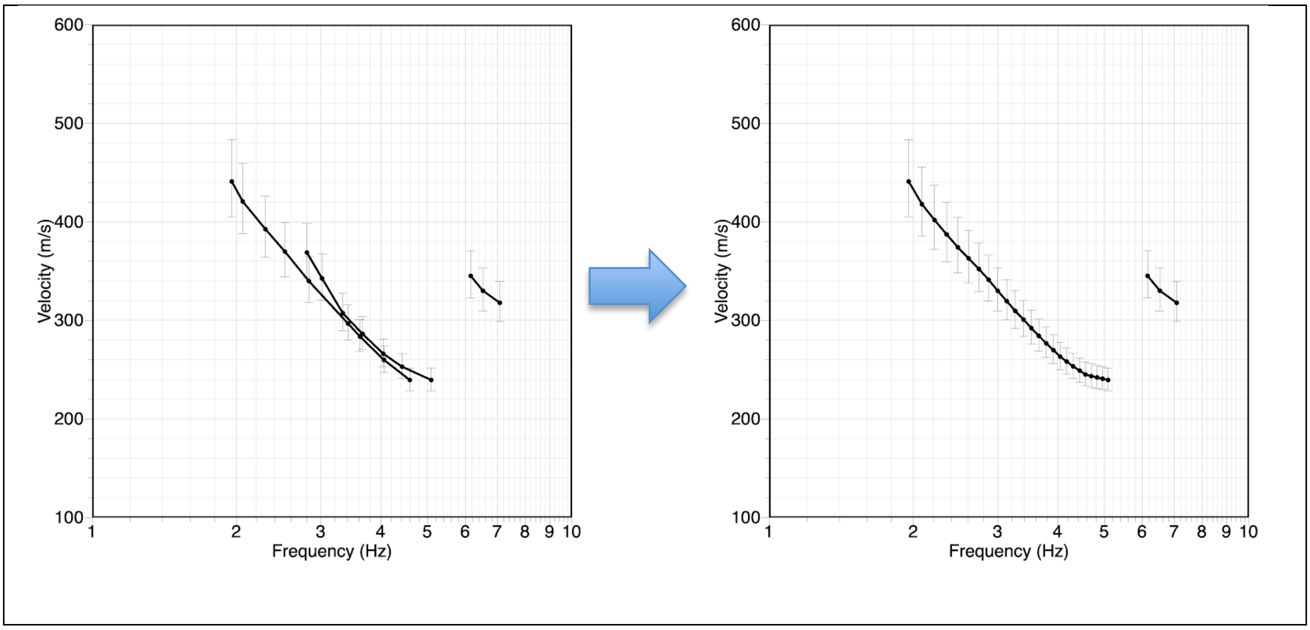

Figure 5: Dispersion curves of Array 2 and 3 (left-hand panel). The fundamental mode has been averaged and resampled in order to have a dispersion curve (DC) to be used for the inversion (right-hand panel). An error has been added to the final DC.

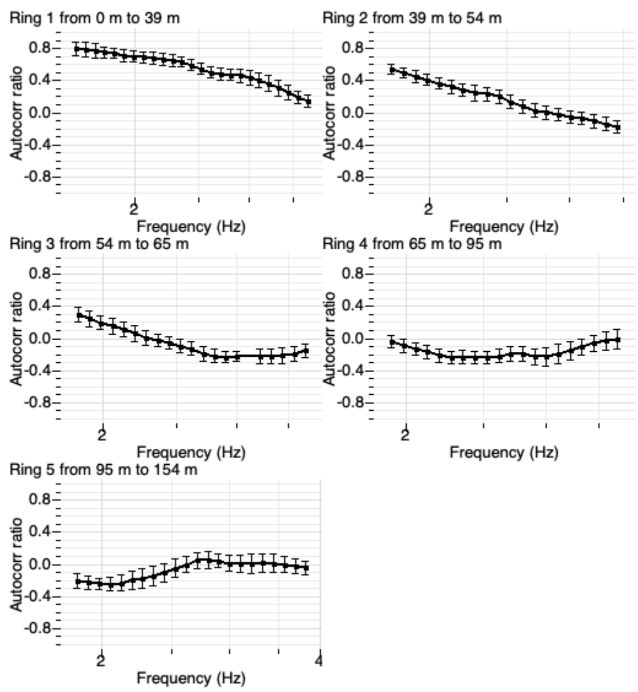

Figure 6: Reliable points of the autocorrelation functions computed using the SPAC analysis on data of Array 3. These curves are the second target of the inversion.

3. SEISMIC VELOCITY MODEL

To proceed with the inversion, we decided to:

1) Invert the dispersion curve showed in Figure 5 (right-hand side) consisting of the fundamental and the first higher mode of Rayleigh waves;
2) Invert jointly the autocorrelation functions carried out from the SPAC analysis;
3) Not to consider the ellipticity constrain, because the reliable H/V curve is flat.

The alleged geology [3] of the area where the IV-BIOG station is installed is a thick layer (more than one hundred meters) of a unit known as "Argilliti Policrome del Calaggio" of Miocen age. In short, it consists of alternate layers of shales and marls.

With this information in mind, we decided to start the inversion with a linearly increasing velocity model with depth. Several tests have been carried out and the final results of the inversion are shown in Figure 7 along with the fit with the two targets.

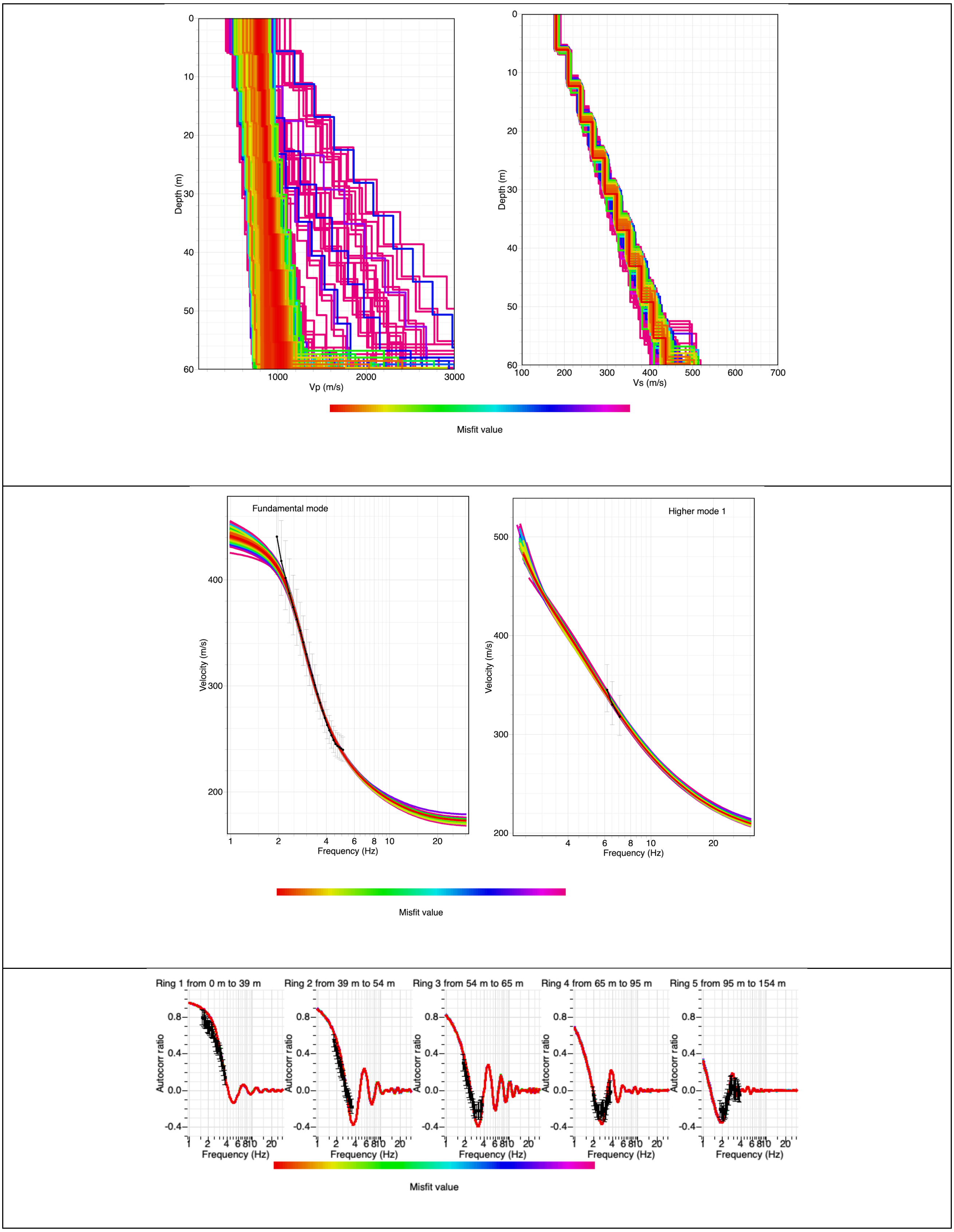

Figure 7: Top panel: Vp and Vs profiles obtained through the inversion of the dispersion curve of Figure 5 and the autocorrelation function of Figure 6. Middle panel: fit between the experimental dispersion curve and the theoretical dispersion curves of the investigated models, for both fundamental and higher modes. Bottom panel: fit between the experimental and modeled autocorrelation functions.

The inversion is able to reproduce fairly well both the experimental dispersion curve and the autocorrelation functions.

The best -fit models of V_p and V_s are represented in Figure 8 and Table 1.

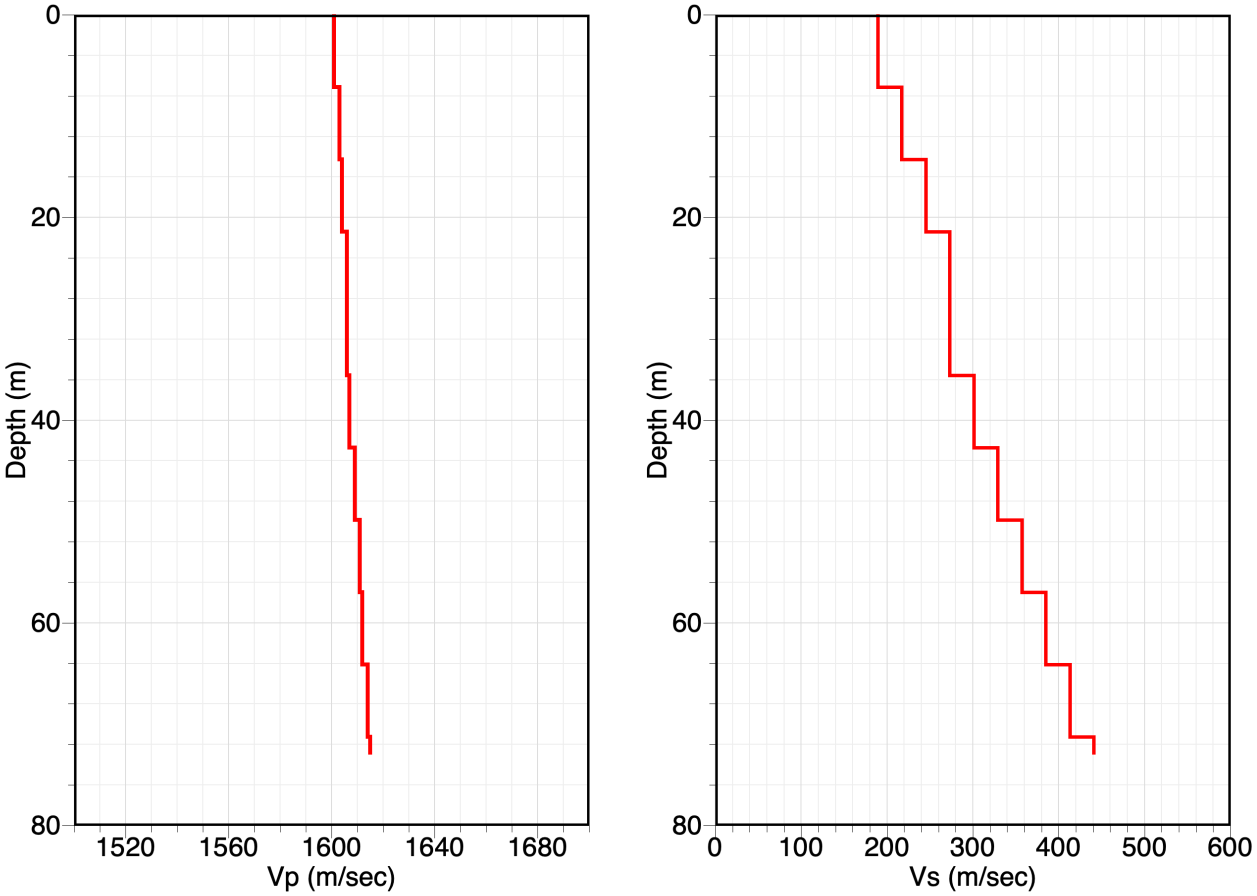

Figure 8: Best-fit models of Vp (left panel) and Vs (right panel) values

From	*To*	*Thickness (m)*	*V_s (m/s)*	*V_p (m/s)*
0	7.14	7.14	189	1601
7.14	14.28	7.14	217	1603
14.28	21.42	7.14	245	1604
21.42	35.56	7.14	273	1606
35.56	37.95	2.39	301	1607
37.95	42.7	4.75	301	1607
42.7	49.84	7.14	329	1609
49.84	56.98	7.14	357	1611
56.98	64.12	7.14	385	1612
64.12	71.26	7.14	413	1614
71.26	78.40	7.14	441	1615

Table 1: Best-fit model

4. CONCLUSIONS

According to the current Italian seismic code [1], if the bedrock (Vs > 800 m/s) is more than 30 m in depth, the equivalent velocity ($V_{s,eq}$) is equal to the $V_{S,30}$. From Figure 8, the velocity of 800m/s is reached for an unknown depth, well above the depth of 30mt. Therefore the equivalence between $V_{s,eq}$ and $V_{S,30}$ is the case to consider for the IV.BIOG site, where the $V_{S,30}$ retrieved from the inversion of the dispersion curves is 229.4 m/s, and the site is classified in the soil category C for both the NTC18 and EC8 seismic classifications (Table 2).

This value is in agreement with other geophysical measurements available in the area [4].

We have to take into account that the inversion process of the data array is poorly constrained by other independent information for this site. The results can change adding this info, whenever available.

$V_{s,eq} = V_{s30}$ [m/s]	Soil class (NTC 2018)	Soil class (EC8)
229.4	C	C

Table 2: Soil Class

REFERENCES

[1] EC8: European Committee for Standardization (2004). Eurocode 8: design of structures for earthquake resistance. P1: General rules, seismic actions and rules for buildings. Draft 6, Doc CEN/TC250/SC8/N335.

[2] NTC 2018: Ministero delle Infrastrutture e dei Trasporti (2018). Aggiornamento delle Norme Tecniche per le Costruzioni. Part 3.2.2: Categorie di sottosuolo e condizioni topografiche, Gazzetta Ufficiale n. 42 del 20 febbraio 2018 (in Italian).

[3] Working group INGV "Agreement DPC-INGV 2019-21. All.B2 – WP1, Task 2", (2019). Geological report at the seismic station IV.BIOG. doi: http://hdl.handle.net/2122/12983

[4] Indagine sismica eseguita per i lavori di completamento della sede della Bio.Ge.M. ed attivazione del centro Biostart, Via Camporeale Area PIP-Ariano Irpino (AV), Prospezione MASW – Allegato 4 da "STUDIO GEOLOGICO A CORREDO DEL PROGETTO PER LA REALIZZAZIONE DI UN POLO PER L'ACCOGLIENZA DEGLI STUDENTI E PER I CONNESSI SERVIZI DIDATTICI E CULTURALI (BIBLIOTECA - MUSEO - SALA CONVEGNI)", Realizzato da GEO group s.r.l. - Via Vitale n° 35 – 83031 Ariano Irpino (AV).

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INGV contributes, within the limits of its skills, to the evaluation of seismic and volcanic hazard in the Country, according to the mode agreed in the ten-year program between INGV and DPC February 2, 2012 (Prot. INGV 2052 of 27/2/2012), and to the activities planned as part of the National Civil Protection System.

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