



NATIONAL OBSERVATORY OF
ATHENS
INSTITUTE OF GEODYNAMICS
P.O. 20048, 11810 Athens
Tel. 2103490172, Fax. 2103490173
e-mail: accelnet@noa.gr



PRELIMINARY REPORT

The Mw5.2 Magoula, Greece earthquake of 19 July 2019

Dr. NIKOLAOS MELIS, Dr. IOANNIS KALOGERAS

Seismologists, Research Directors

Dr. NIKOS KALLIGERIS

Civil Engineer, Principal Researcher

Tel. +30 2103490190, +30 2103490172, +30 2103490165
e-mail: nmelis@noa.gr, i.kalog@noa.gr, nkalligeris@noa.gr

ATHENS, SEPTEMBER 2019

Foreword

This brief report is being issued as part of the National Accelerographic Network due to the particular interest in the recent Mw5.2 earthquake on 19/7/2019, 11:13 (GMT), with the epicenter lying in the general area of Magoula (Attica), Greece (strong earthquake, small epicentral distance from the Athens city complex). The report includes information on the processing of the instrumental recordings corresponding to the main event and the two most significant aftershocks on 19/7/2019, 12:12 (UTC) and 28/7/2019, 16:09 (UTC), of magnitudes Mw4.4 and Mw4.2, respectively. Preliminary observations are noted in conjunction with seismic intensity maps derived from all available instrumental recordings and macro-seismic data collected by the European-Mediterranean Seismological Centre (EMSC) which are available to the research community and general public.

This report should be cited as:

Melis, N.S., Kalogeras, I. and Kalligeris, N. (2019). Preliminary results of the processing of the Institute of Geodynamics accelerographic network recordings for the Mw5.2 earthquake of 19 July 2019 (general area of Magoula, Attica). *Preliminary report, Institute of Geodynamics, page 15.*

Introduction

A strong earthquake of magnitude Mw5.2 occurred on 19/7/2019, 14:13 local time, with the epicenter lying in the general area of Magoula, Attica (38.1184N, 23.5295E, 11km). The main event was followed by a series of aftershocks, with the most significant being the following two: (1) a Mw4.4 event on the same day at 15:12 (local time), and (2) a Mw4.2 event on 28/7/2019 19:09 (local time). The series of aftershocks was of small duration and the magnitudes were generally low (besides the two aforementioned aftershock events). The moment tensor solution of the main event shows normal faulting along an almost E-W direction (Strike: 106, Dip: 61, Rake: -84), revealing that the rupture occurred on the same fault but just west of the Mw5.9 earthquake on 7/9/1999. Figure 1 shows the seismic activity of the area for the period between 19/7/2019-30/8/2019, and the seismic mechanisms of the main earthquake event and the two most significant aftershocks (source: <http://bbnet.gein.noa.gr>); the epicenter (Baumont et al., 2004) and seismic mechanism (Zahradnik 2002) of the 1999 magnitude Mw5.9 earthquake are also plotted.

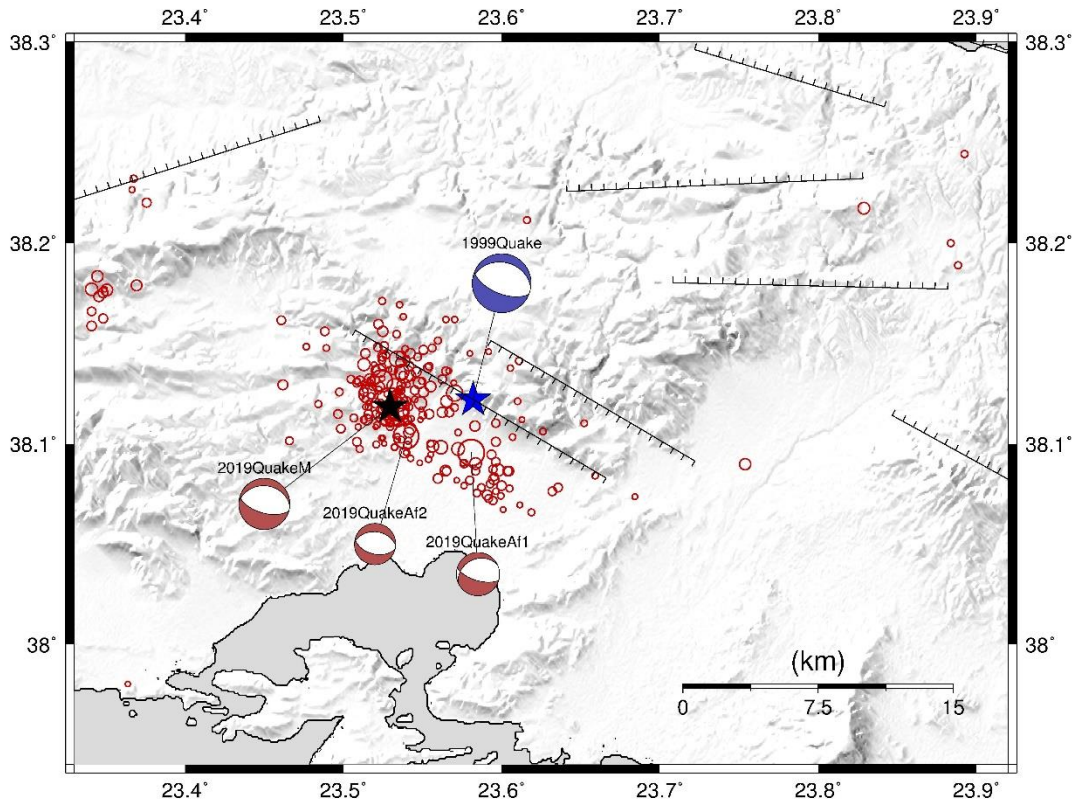


Figure 1. The seismicity of the study area corresponding to the period between 19/7/2019 – 30/8/2019. The black star denotes the epicenter of the recent main event and the blue star shows the epicenter of the 7/9/1999 earthquake. The figure also shows the seismic mechanism of the most significant aftershocks of magnitudes Mw4.4(Af1) and Mw4.2(Af2), respectively (source: <http://bbnet.gein.noa.gr>), as well as the main faults in the general area of Attica, Greece (source: Deligiannakis et al., 2018).

Figure 2 shows the macro-seismic observations collected by EMSC and the seismic intensity inferred from the instrumental peak ground acceleration (PGA) recorded at the accelerographic and seismographic stations of the Hellenic Seismic Network. The color coding of the points reveals similar intensities between the two source types. A more detailed description is provided later on.

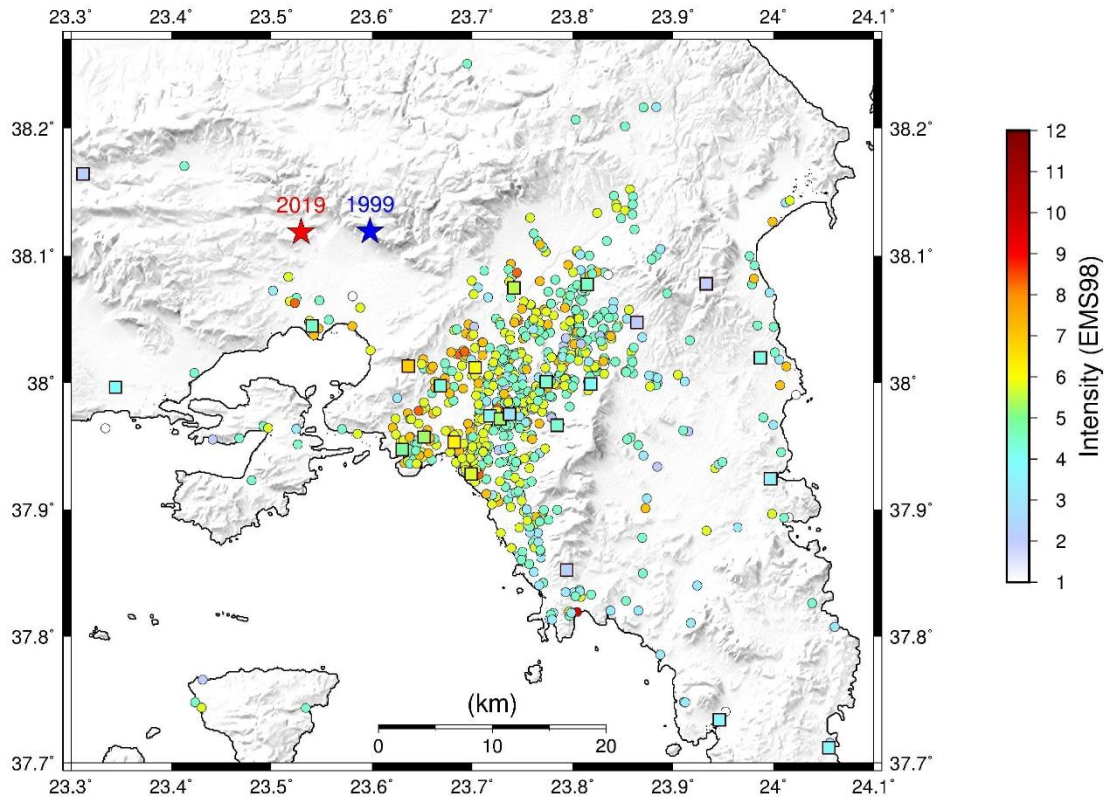
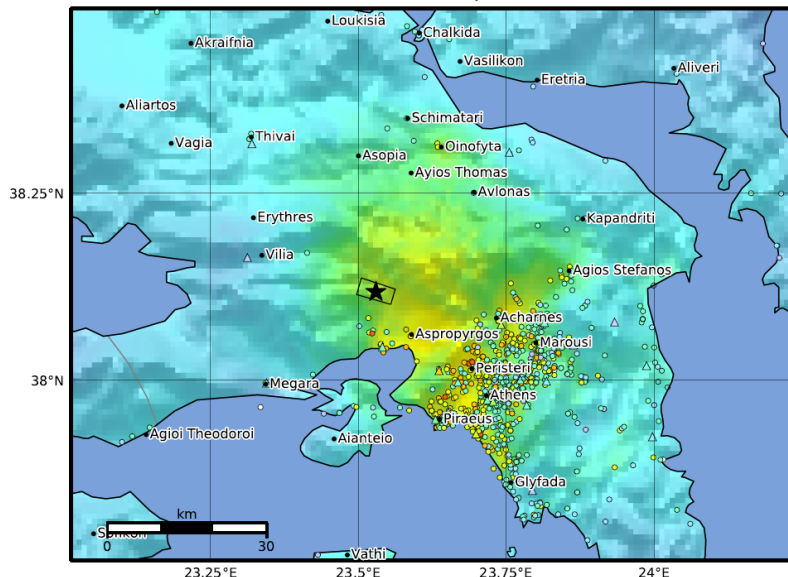


Figure 2. Macro-seismic intensity map of the EMSC data (circles color-coded according to the intensity value) and validation of the local seismic intensity through the intensity inferred from the peak ground acceleration (PGA) recorded by accelerographs or seismographs of the Hellenic Seismic Network. Macro-seismic intensity does not exceed VI+ (corresponding to strong shaking) in the general area of Dafni. The blue and red stars denote the epicenters of the 7/9/1999 and the recent 19/7/2019 earthquakes, respectively (see figure 1 and text for references).

Figure 3 shows two maps for: (a) seismic intensity and (b) estimated peak ground acceleration (PGA), as produced through the operational application of ShakeMap 4.0 (USGS) in the Institute of Geodynamics (source: <https://accelnet.gein.noa.gr>). EMSC macro-seismic observations are included using empirical relations between PGA and intensity (see Bossu et al., 2011 and 2018). Macro-seismic intensity does not exceed VI+ (corresponding to strong shaking).

Macroseismic Intensity Map
 NOAIG ShakeMap: noa2019oanjd / 38.11843872 / 23.5295105
 Jul 19, 2019 11:13:15 UTC M5.3 N38.12 E23.53 Depth: 13.1km
 ID:noa2019oanjdf

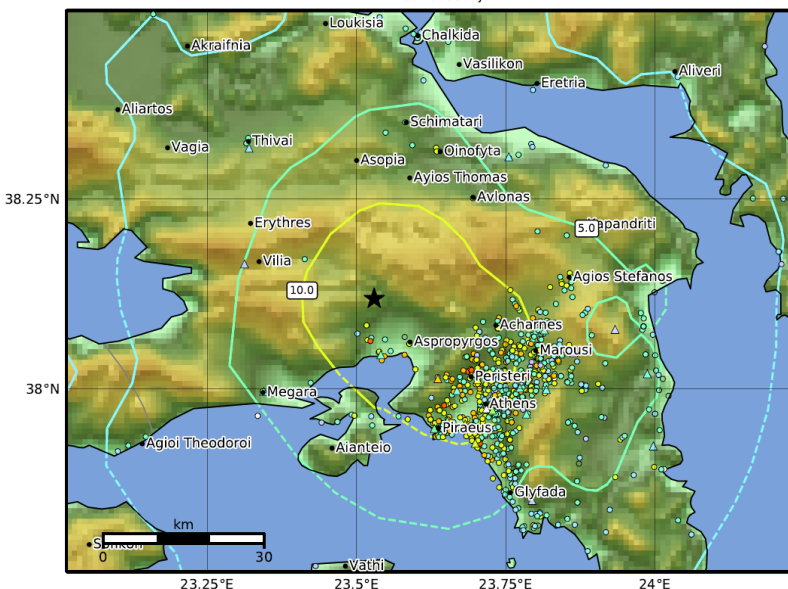


SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	None	None	None	Very light	Light	Moderate	Moderate/heavy	Heavy	Very heavy
PGA(%g)	<0.05	0.3	2.76	6.2	11.5	21.5	40.1	74.7	>139
PGV(cm/s)	<0.02	0.13	1.41	4.65	9.64	20	41.4	85.8	>178
INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based on Worden et al. (2012)
 △ Seismic Instrument ○ Reported Intensity ★ Epicenter - - Rupture

(a)

Peak Ground Acceleration Map
 NOAIG ShakeMap: noa2019oanjd / 38.11843872 / 23.5295105
 Jul 19, 2019 11:13:15 UTC M5.3 N38.12 E23.53 Depth: 13.1km
 ID:noa2019oanjdf



PGA (%g)	0.1	0.2	0.5	1	2	5	10	20	50	100	200
----------	-----	-----	-----	---	---	---	----	----	----	-----	-----

Scale based on Worden et al. (2012)
 △ Seismic Instrument ○ Reported Intensity ★ Epicenter

(b)

Figure 3. Maps, products of the applications of ShakeMap 4.0 (USGS) using all the available data from the seismological stations (seismographs, accelerographs) and the observations collected by EMSC, showing: (a) seismic intensity distribution and the fault

rupture area of the main event, and (b) PGA distribution. Intensity inferred from the instrumental recordings reaches VI+ in the immediate affected area.

Macro-seismic intensity inferred from the descriptions of the observers (data collected by EMSC) and the media, agrees with a VI+ estimate, i.e. corresponding to the fall of small to medium objects, some furniture is moved, some slight damages, most of the public panicking within the immediate affected area etc.

Earthquake recordings from the accelerographic network of NOA - Institute of Geodynamics in the greater Attica region.

The accelerographic network of NOA - Institute of Geodynamics, in the greater Attica region, consists of digital instruments of two different generations: a) the older generation digital instruments of type A800 / A900 (Teledyne company, sampling rate 200 s/s @ 12/16 bit) and QDR (Kinematics company, sampling rate 100 s/s @ 11 bit) are operating on triggering mode based on setting a threshold acceleration limit, and b) the most modern digital instruments of type CMG-5TDE (Guralp Systems company, sampling rate 200 s/s @ 24 bit) in continuous real time monitoring operation with data sent to the Athens center recording servers for automatic processing and archiving.

The main earthquake event was recorded from a variety of instruments deployed in the greater Attica region, except from those that were out of operation (Rentis – RNTA, Ilion – LIOA, Chalkida – CHAA), and those that were not triggered since the threshold was not exceeded (Oinophyta – OINA), although the epicentral distance was rather short (~23 km). The accelerograph at Oinophyta that was not triggered (PGA threshold was set to 8 cm/s²) must be investigated at a later stage, since instruments of the same type at longer distances such as Oropos (28 km) and Vravra (46 km) were triggered (same threshold applied to all three instruments).

For the recordings of the first generation instruments, the processing was made following the methodology developed under the framework of the Greek Unified Earthquake Strong Motion Database HEAD v1.0 (Theodulidis et al., 2004), setting filter values fl according to the type of instrument and the characteristics of the recording fh1=25 Hz and fh2=27 Hz. For the second category instruments, software ART was used with typical filter values fl=0.300 Hz, fh1=25 Hz and fh2=30 Hz. However, the raw recordings can be made available after request, and the user can apply a variety of filtering values according to the interest of application. Tables I-III present the values of maximum strong ground acceleration, velocity and displacement, respectively, for every recording component and accelerographic station of NOA-Institute of Geodynamics network for distances up to 100km from the epicenter for the main event (Table I) and the two largest aftershocks (Tables I-II).

α) A particular mention should be made to the collapse of the outer wall enclosure in the area of the Dafni Monastery, which coincides with the maximum strong ground motion acceleration value recorded for the main event (410 cm/s^2) at the accelerograph of NOA-IG (QDR type – station code MDFB) at a nearby location (Figure 5). In Figure 4, the location of the accelerograph station at the outer enclosure of the archaeological site is shown, in relation to the location where the outer wall collapsed. It is also interesting, that despite the disadvantages of the instrument technical characteristics (old generation instrument), the lower excitation threshold was exceeded not only during the two major aftershocks events, but also during $\sim M3.5$ aftershocks.

b) Despite the location of the Elefsina station (ELFA) lying closer to the epicenter than the Dafni Monastery (8 km vs 15 km, respectively), the maximum values of strong ground motion are clearly lower than those observed at Dafni Monastery. Local conditions and the influence of the building response should be taken into account to further investigate this observation; the MDFB station corresponds to a free field instrument deployment, while the ELFA deployment lies inside the building (in the basement of the Town Hall).

c) Figure 6 compares the records of station ATHA (Neo Psychiko) for the damaging earthquake of 07/09/1999 Mw5.9 and the recent Mw5.1 event of 19/7/2019. The recording of the 1999 event was made using an old generation instrument of type A800 (12 bit @ 200 s/s), while the 2019 event was recorded by a modern instrument of type CMG-5TDE (24 bit @ 200 s/s). For both recordings, the vault is the same and the epicentral distances are almost equal. The maximum values of PGA strong ground motion (cm/s^2) that were recorded at each component are: (1999 event) N-S 82 cm/s^2 , Z 112 cm/s^2 , E-W 99 cm/s^2 and (2019 event) N-S 41 cm/s^2 , Z 39 cm/s^2 , E-W 62 cm/s^2 . The peak acceleration for the 1999 event is observed at the vertical component, while for the recent event it is clearly lower than the two horizontal components. Figure 7 shows the comparison of the response spectra for both earthquakes in all three components.

d) In the area of Piraeus port (western jetty), there was a partial collapse of the conveyor belt used for fertilizer transportation, constructed in the inter-war period (Figure 8), that had obvious signs of corrosion of its building materials (concrete and reinforcement). About 1000m away from the collapsed construction, there is an accelerometric station deployed at the basement of Drapetsona Town Hall. The accelerograph, type CMG-5TDE, recorded the main strong event and all aftershocks, and the maximum PGA value was measured at 117 cm/s^2 (epicentral distance of 21 km). Further evaluation of this observation should take into account the impact of the Town Hall building on the recording, which is a massive asymmetric building in height, but also the different foundation at the two structures on the background, which in both places is Pleistocene marl limestones and sandstones, respectively.



Figure 4. The position of the accelerograph (triangle) in the enclosure of the archaeological site of Dafni in relation to the site where the northern perimeter wall collapsed (star), the instrument installation and the wall collapse due to the earthquake.

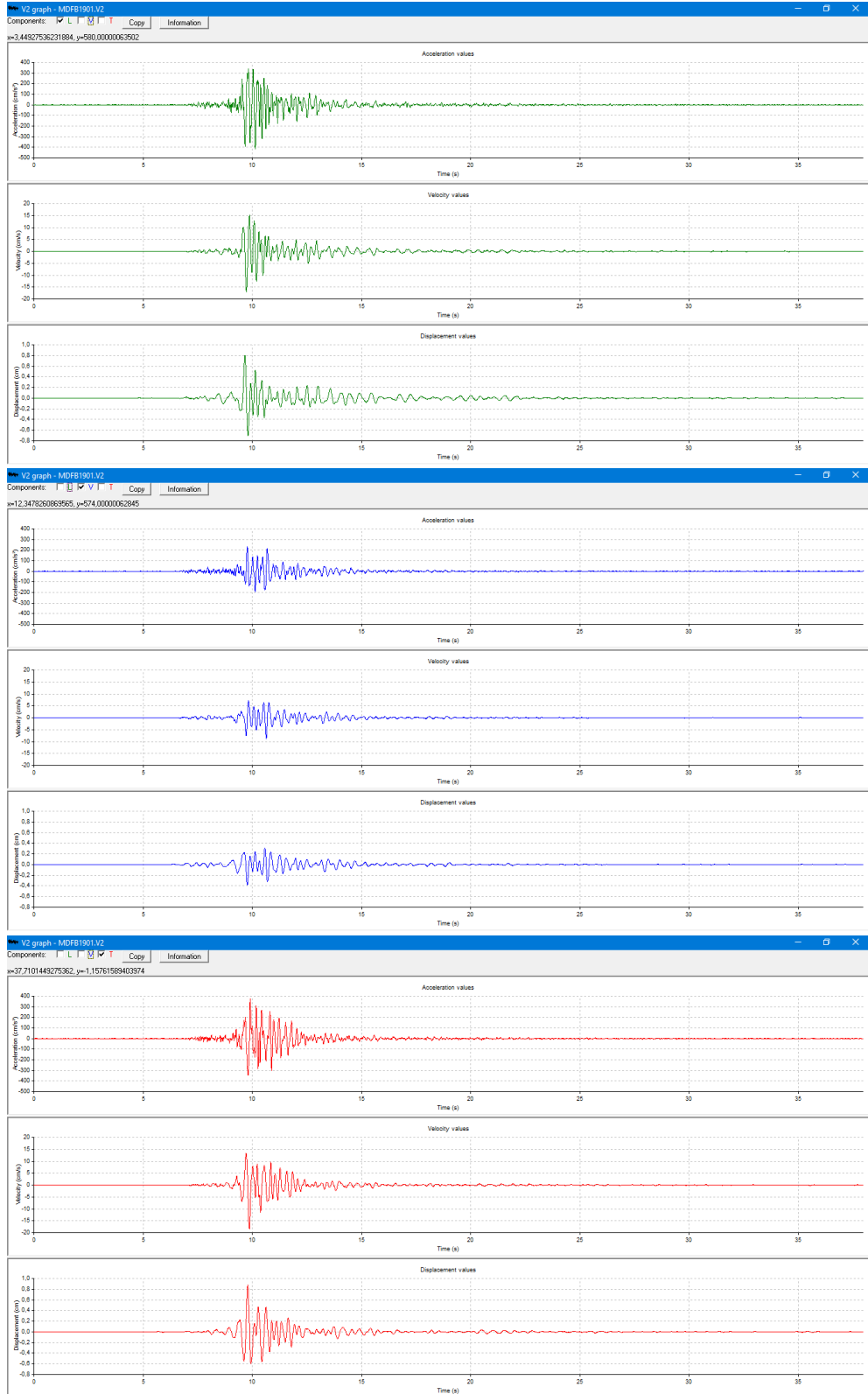


Figure 5. The corrected time series of ground acceleration, ground velocity and ground displacement of the instrument at Dafni Monastery, where maximum values per component were recorded (Z – blue, N280 – green, N190 – red).

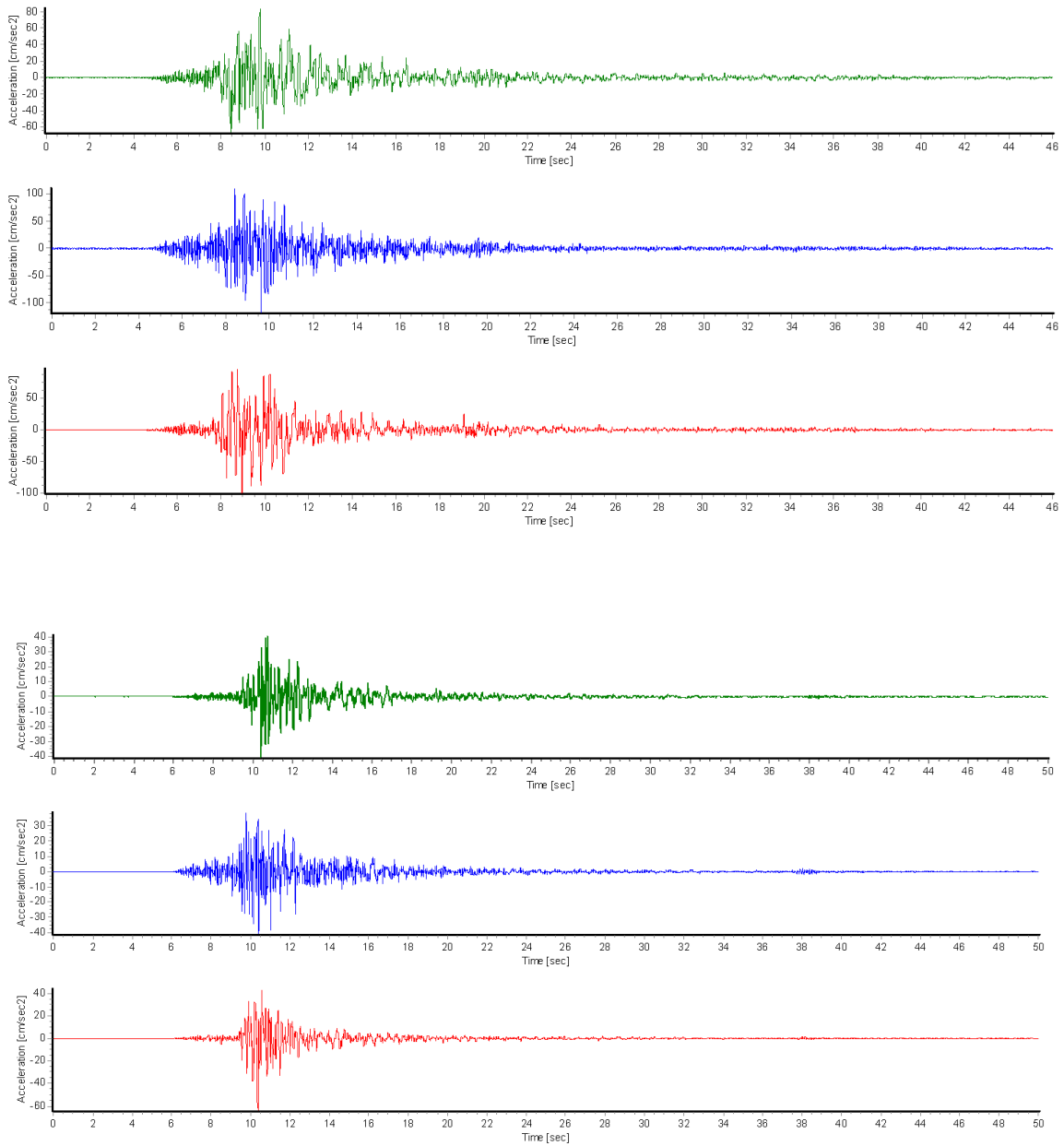


Figure 6. Comparative presentation of accelerometric recordings for the earthquakes of 07/09/1999 Mw5.9 (top, N-S, Z, E-W) and 19/07/2019 Mw5.1 (bottom, N-S, Z, E-W) for the ATHA station.

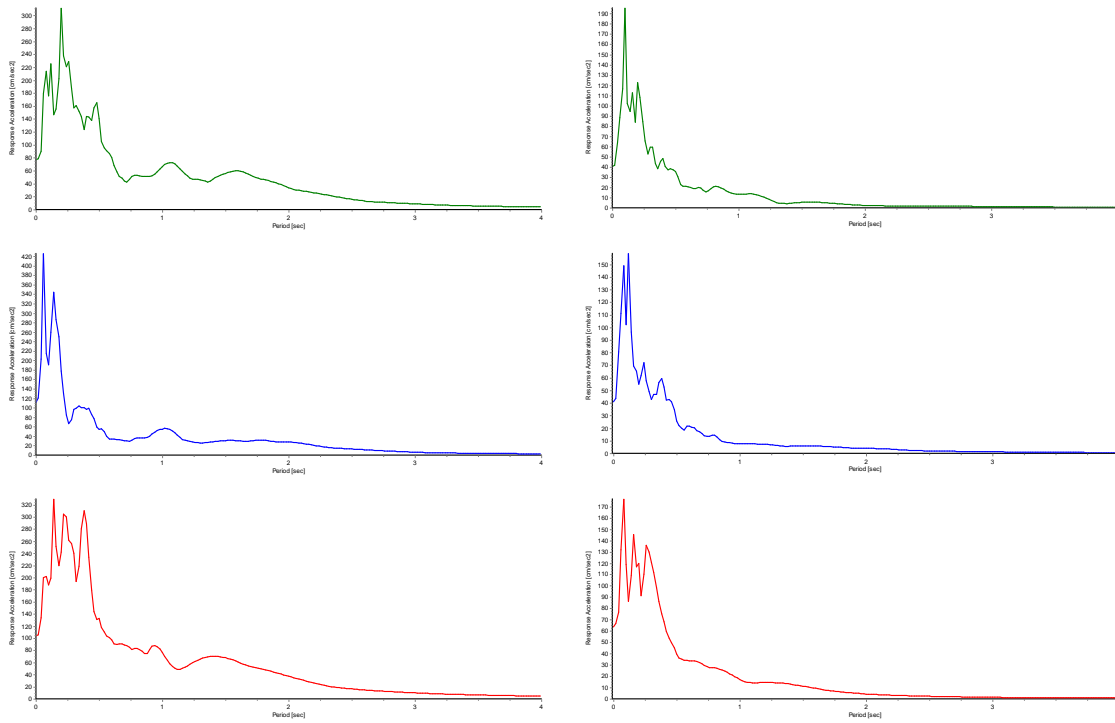


Figure 7. Response spectra for damping factor 5% for the earthquakes of 07/09/1999 Mw5.9 (left, N-S, Z, E-W) and 19/07/2019 Mw5.1 (right, N-S, Z, E-W) for the ATHA station.

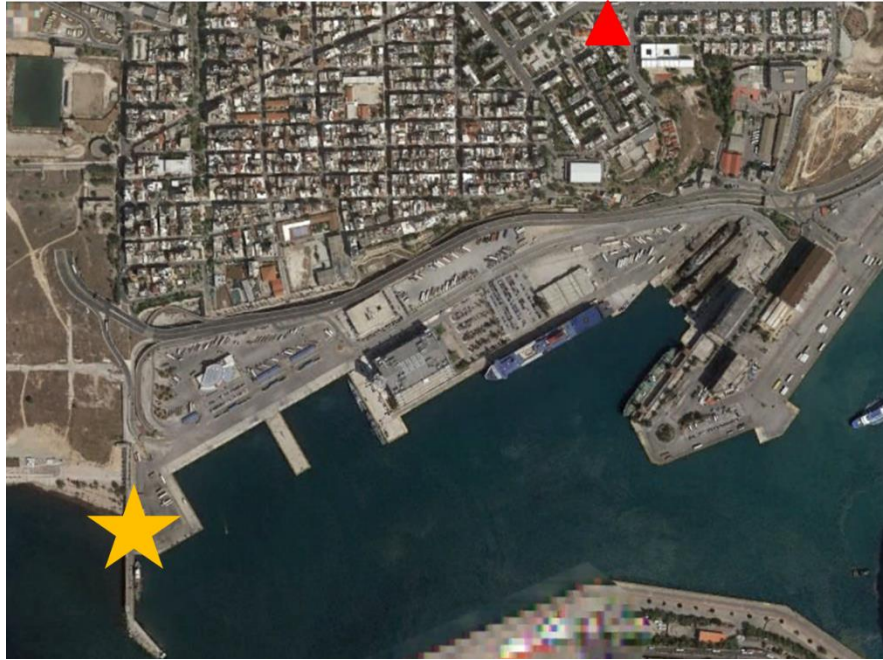


Figure 8. Map of Drapetsona area (top) that shows with a triangle the location of accelerograph in the basement of City Hall (bottom left) and with star the site of collapsed beltway (bottom right) due to the main event of 19/7/2019.

References

- Baumont D., Scotti, O., Courboux, F. and Melis, N., 2004. Complex kinematic rupture of the Mw 5.9, 1999 Athens earthquake as revealed by the joint inversion of regional seismological and SAR data. *Geophys. J. Int.*, 158, 1078-1087, doi: 10.1111/j.1365-246X.2004.02374.x.
- Bossu, R., Gilles, S., Mazet-Roux, G. and Roussel, F., 2011. Citizen Seismology or How to Involve the Public in Earthquake Response. *Comparative Emergency Management: Examining Global and Regional Responses to Disasters*. Editors: D. M. Miller and J. Rivera. Auerbach/Taylor and Francis Publishers. Chapter 11, 237-259
- Bossu, R., Roussel, F., Fallou, L., Landès, M., Steed, R., Mazet-Roux, G., Dupont, A., Frobert, L. and Petersen, L., 2018. LastQuake: From rapid information to global seismic risk reduction. *International Journal of Disaster Risk Reduction*, 28, 32–42. doi: 10.1016/j.ijdr.2018.02.024.
- Deligiannakis, G., Papanikolaou, I.D. and Roberts, G., 2018. Fault specific GIS based seismic hazard maps for the Attica region, Greece. *Geomorphology*, 306, 264-282, doi: 10.1016/j.geomorph.2016.12.005.
- European Mediterranean Seismological Centre (EMSC), <https://www.emsc-csem.org/#2>
- Theodulidis, N., Kalogeras, I., Papazachos, C.B., Karastathis, V., Margaris, B.N., Papaioannou, Ch. and Skarlatoudis, A.A., 2004. HEAD v1.0: A unified Hellenic Accelerogram Database, *Seis. Res. Lett.*, 75, 36-45, doi: 10.1785/gssrl.75.1.36
- Zahradnik, J., 2002. Focal mechanism of the Athens 1999 earthquake by ASPO method, Research report, Department of Geophysics, Charles University, Prague.

TABLE I

Maximum values of strong ground motion for the Mw5.1 earthquake of 19/7/2019 11:13 for sites at epicentral distance up to 100km.

CODE	LOCATION	INST	EP.DIST.	COMP	ACC	VEL	DISP	COMP	ACC	VEL	DISP	COMP	ACC	VEL	DISP
ELFA	Elefsina	CMG	8	N315	71.479	2.434	0.333	N45	80.488	2.982	0.634	Z	67.711	2.968	0.423
MDFB	Moni Dafniou	QDR	15	N100	377.300	18.500	0.882	N190	413.500	17.070	0.792	Z	232.400	8.745	0.387
AGLA	Aigaleo	QDR	18	N285	57.080	2.220	0.124	N195	67.48	1.745	0.070	Z	38.340	1.330	0.079
ACHA	Acharnes	CMG	19	N20	225.780	6.792	0.609	N110	251.720	7.112	0.386	Z	176.250	4.970	0.265
DRPA	Drapetsona	CMG	21	N270	81.774	4.526	0.714	N0	117.186	3.272	0.396	Z	68.265	2.284	0.400
MGRA	Megara	A800	21	N60	48.560	1.506	0.080	N330	41.850	1.443	0.054	Z	25.750	0.835	0.039
NOAC	Thissio	CMG	23	N0	97.552	3.100	0.367	N90	126.165	6.441	0.361	Z	51.910	2.266	0.298
ACRA	Acropolis	CMG	24	N0	43.744	2.199	0.285	N90	106.88	5.926	0.572	Z	27.264	1.730	0.325
ATHA	Neo Psychiko	CMG	25	N0	40.838	1.422	0.130	N90	61.994	2.624	0.232	Z	38.728	1.349	0.141
PLFA	Palaio Faliro	A800	26	N30	39.090	2.756	0.321	N120	95.280	7.858	0.867	Z	33.470	1.658	0.340
ORPA	Oropos	QDR	28	N170	18.300	0.988	0.079	N80	14.36	0.635	0.043	Z	15.13	0.537	0.036
DMKB	Ag. Paraskevi	A800	28	N140	37.680	1.531	0.089	N230	41.060	1.305	0.063	Z	28.070	0.662	0.032
RFNA	Rafina	A800	42	N330	45.690	2.035	0.089	N60	45.190	1.586	0.087	Z	24.620	0.602	0.040
VRVA	Vravrona	QDR	46	N100	13.280	0.434	0.019	N10	13.740	0.644	0.037	Z	10.200	0.492	0.030
ANVA	Anavyssos	A800	56	N210	20.310	0.963	0.216	N300	19.75	0.505	0.105	Z	12.260	0.532	0.049
KORA	Korinthos	A800	56	N120	11.170	0.354	0.020	N210	10.01	0.452	0.026	Z	6.949	0.205	0.014
LVRA	Lavrio	CMG	65	N30	11.002	0.908	0.123	N120	12.162	0.374	0.036	Z	6.055	0.400	0.049
KIAA	Kiato	CMG	69	N40	6.658	0.306	0.059	N130	4.068	0.302	0.072	Z	3.004	0.153	0.041
YDRA	Ydra	CMG	86	N0	4.379	0.202	0.024	N90	4.209	0.241	0.054	Z	2.614	0.118	0.030
NPLA	Nafplio	CMG	89	N190	1.852	0.089	0.030	N180	1.994	0.128	0.027	Z	0.978	0.055	0.023
AIDA	Aidipsos	CMG	92	N130	1.045	0.081	0.018	N220	1.500	0.090	0.014	Z	1.069	0.057	0.010
DLFA	Delfoi	CMG	99	N230	0.953	0.060	0.006	N320	1.031	0.052	0.009	Z	1.088	0.054	0.010

TABLE II

Maximum values of strong ground motion for the Mw4.4 earthquake of 19/7/2019, 12:11, for sites at epicentral distance up to 100km.

CODE	LOCATION	INST	EP.DIST.	COMP	ACC	VEL	DISP	COMP	ACC	VEL	DISP	COMP	ACC	VEL	DISP
ELFA	Elefsina	CMG	6	N315	11.466	0.373	0.030	N45	20.514	0.730	0.102	Z	17.896	0.743	0.070
MDFB	Moni Dafniou	QDR	11	N100	78.460	2.839	0.098	N190	116.800	3.277	0.162	Z	75.310	2.524	0.112
AGLA	Aigaleo	QDR	14	N285	8.179	0.314	0.018	N195	12.670	0.266	0.010	Z	7.524	0.257	0.013
ACHA	Acharnes	CMG	15	N20	21.669	0.532	0.051	N110	31.663	0.710	0.026	Z	15.925	0.474	0.023
DRPA	Drapetsona	CMG	17	N270	18.150	0.704	0.059	N0	28.84	0.685	0.042	Z	9.699	0.458	0.042
NOAC	Thissio	CMG	18	N0	7.784	0.245	0.026	N90	15.427	0.459	0.027	Z	8.110	0.269	0.022
ACRA	Acropolis	CMG	19	N0	4.446	0.202	0.021	N90	10.807	0.461	0.037	Z	2.532	0.098	0.018
ATHA	Neo Psychiko	CMG	20	N0	6.456	0.134	0.012	N90	7.513	0.174	0.017	Z	11.856	0.153	0.010
PLFA	Palaio Faliro	A800	22	N30	10.860	0.374	0.031	N120	11.900	0.608	0.061	Z	9.848	0.220	0.032
MGRA	Megara	A800	23	N60	9.580	0.250	0.014	N330	11.250	0.455	0.028	Z	6.696	0.158	0.008
RFNA	Rafina	A800	37	N330	8.003	0.172	0.005	N60	7.425	0.136	0.005	Z	4.844	0.088	0.004
ANVA	Anavyssos	A800	52	N210	7.020	0.234	0.039	N300	5.123	0.215	0.059	Z	3.901	0.133	0.030
LVRA	Lavrio	CMG	60	N30	3.508	0.084	0.010	N120	2.764	0.070	0.003	Z	1.648	0.046	0.004
KIAA	Kiato	CMG	73	N40	0.983	0.077	0.011	N130	1.084	0.081	0.011	Z	0.535	0.034	0.006
YDRA	Ydra	CMG	83	N0	0.929	0.036	0.004	N90	0.906	0.057	0.005	Z	0.488	0.021	0.002
NPLA	Nafplio	CMG	90	N190	0.401	0.026	0.003	N180	0.525	0.039	0.004	Z	0.227	0.011	0.002
AIDA	Aidipsos	CMG	96	N130	0.189	0.016	0.003	N220	0.209	0.013	0.002	Z	0.359	0.014	0.001

TABLE III

Maximum values of strong ground motion for the Mw4.2 earthquake of 28/7/2019, 16:09, for sites at epicentral distance up to 100km.

CODE	LOCATION	INST	EP.DIST.	COMP	ACC	VEL	DISP	COMP	ACC	VEL	DISP	COMP	ACC	VEL	DISP
ELFA	Elefsina	CMG	7	N315	12.389	0.474	0.043	N45	16.243	0.674	0.098	Z	13.811	0.624	0.056
MDFB	Moni Dafniou	QDR	13	N100	26.72	0.890	0.046	N190	27.46	0.763	0.044	Z	20.13	0.335	0.022
ACHA	Acharnes	CMG	18	N20	13.552	0.336	0.017	N110	17.599	0.463	0.024	Z	9.201	0.300	0.023
DRPA	Drapetsona	CMG	19	N270	7.896	0.248	0.020	N0	9.716	0.303	0.030	Z	5.980	0.136	0.014
NOAC	Thissio	CMG	21	N0	3.199	0.095	0.012	N90	4.534	0.116	0.011	Z	2.618	0.090	0.007
ATHA	Neo Psychiko	CMG	24	N0	4.881	0.096	0.005	N90	5.239	0.093	0.008	Z	5.496	0.105	0.007
MGRA	Megara	A800	21	N60	9.844	0.285	0.019	N330	11.43	0.341	0.019	Z	9.286	0.430	0.023
RFNA	Rafina	A800	40	N330	5.865	0.130	0.004	N60	7.646	0.155	0.004	Z	3.865	0.078	0.006
LVRA	Lavrio	CMG	63	N30	1.276	0.040	0.005	N120	1.511	0.032	0.002	Z	0.737	0.026	0.002
KIAA	Kiato	CMG	70	N40	0.942	0.052	0.007	N130	0.955	0.044	0.008	Z	0.514	0.020	0.004
YDRA	Ydra	CMG	84	N0	0.718	0.029	0.003	N90	0.988	0.061	0.005	Z	0.434	0.013	0.001
NPLA	Nafplio	CMG	88	N190	0.300	0.017	0.002	N180	0.282	0.015	0.002	Z	0.158	0.006	0.001
AIDA	Aidipsos	CMG	94	N130	0.234	0.017	0.002	N220	0.326	0.017	0.002	Z	0.482	0.017	0.001