GEOLOGICAL AND GEODETIC DEFORMATION ALONG THE ACTIVE NORTHERN MARGIN OF THE HYBLEAN PLATEAU (SE SICILY): EVIDENCE FOR A NEW POTENTIAL SEISMOGENIC SOURCE.

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Abstract

A geologic and geodetic integrated analysis of the northern margin of the Hyblean Plateau (SE Sicily) has been carried out in order to test the relation of the active deformation, recorded by GPS data, and the long-term tectonic evolution, recorded by structural and morphological data, with potential seismogenic sources of the region, where high level (MCS I_0 = X – XI) historical seismicity occurred. To date, seismotectonic models have alternatively related the main seismogenic sources to the incipient rifting that reactivated the Malta Escarpment in the Ionian off-shore or to the still active NW-SE trending Nubia-Eurasia convergence, that remobilized the northern tectonic boundary of the Hyblean Plateau. In this region, the new data reveals that the active deformation can be framed in the flexural tectonics developed during the late stages of the Nubia-Eurasia plate convergence. Geodetic and geological data provide a coherent kinematic picture that is compatible with the occurrence of a blind ramp thrust along the NW margin of the

Hyblean Plateau. This study demonstrates that the onshore seismicity of the Hyblean region can be confidently referred to active compressional dynamics. Additionally, our data candidate the inferred blind thrust, located to the south of the Scordia-Lentini graben, as a major potential seismogenic source that might be considered in interpreting the historical seismicity of the region.

Keywords: ground deformation, geological data, GPS data, Hyblean Plateau, Scordia-Lentini Graben, SE Sicily.

1. INTRODUCTION

In southeastern Sicily, the origin of the high level (MCS I_0 = X – XI) historical seismicity of the Hyblean Plateau (1169; 1542; 1693 A.D.)(WG CPTI11, 2011) is still debated. The current seismotectonic models of the region have alternatively related the main seismogenic sources to one of the two distinct active geodynamic processes that have been concurrent during the entire Late Quaternary in the region. Several Authors (e.g. Adam et al., 2000; Azzaro and Barbano, 2000; Catalano et al., 2008a; Monaco and Tortorici, 2000; Polonia et al., 2012; Scandone and Stucchi, 2000) referred the main seismicity to the incipient rifting that reactivated the Malta Escarpment, along the Ionian off-shore of the Hyblean region, causing the propagation of the Late Quaternary Siculo-Calabrian Rift Zone (**SCRZ**; Monaco and Tortorici, 2000) (Fig. 1). Morphological investigation in the Ionian off-shore, based on a grid of seismic lines (Bianca et al., 1999; Hirn et al., 1997), candidates the active fault segments of the **SCRZ** as possible sources of destructive historical events, according to their parameters and Late Quaternary rates of deformation.

Other Authors (e.g. Sirovich and Pettenati, 1999; Valensise and Pantosti, 2001) constrained the location of the seismogenic sources in the on-shore, linking the main seismicity of the region to the contractional deformation due to the still active NW-SE trending Nubia-Eurasia convergence. Contractional episodes at the front of the SE-verging Apenninic-Maghrebian thrust belt have been reported by previous Authors (Elter et al., 2003; Torelli et al., 1998). These were associated to a generalised positive tectonic inversion (Bousquet and Lanzafame, 2004; Catalano et al., 2010) of the Simeto and Scordia-Lentini extensional Grabens (Bianchi et al., 1987; Ghisetti and Vezzani, 1980) at the northern edge of the Hyblean Foreland.

The contrasting seismotectonic models are mainly based on the macroseismic distribution of the earthquakes and geological and morphological information, as the instrumental seismicity only refers to low-middle Magnitude earthquakes. A recent event, occurred in 1990 (Augusta area), shows focal mechanism (Amato et al., 1995) that constrains the location of the seismogenic source within the contractional domain affected by the NW-SE oriented compression (Fig. 1). Similarly, the focal mechanisms of the low Magnitude seismicity recorded in the Hyblean Plateau from 1994 to 2002 (Musumeci et al., 2005) suggest an active NW-SE to NNW-SSE oriented regional compression. The reconstructed seismogenic stress-tensors are consistent with stress-in-situ measurements (Ragg et al., 1999) and regional scale geodetic data (Hollenstein et al., 2003) documenting a dominant N150 oriented σ_{hmax} direction, associated to a geodetic convergence-rate of about 2.6 mm/y, measured between the Hyblean Plateau and the Tyrrhenian regions of Sicily (USTI and NOTO sites, Fig. 1).

In this paper, we discuss the results of integrated structural, morphological and geodetic analyses of the northern border of the Hyblean Plateau. The study is based on the comparison between the short- and long-term dynamic and kinematic pictures of the region, which were obtained from GPS surveys and from structural and morphostructural analyses, including field mapping of Upper Quaternary marine terraces, morphometric analysis of the drainage system and mesoscale structural analyses on rejuvenated fault planes. The study aims to define the location, the geometry and the significance of the structure responsible for the active deformation, revealed by GPS and by the Middle-Late Pleistocene kinematics, in order to test the existence of a potential seismogenic source within the onshore contractional domain of the Hyblean Plateau.

2. TECTONIC SETTING

The Hyblean Plateau, located at the south-eastern corner of Sicily, is a buoyant crustal block of the Africa foreland that, during the Nubia-Eurasia plates collision, acted as an indenter deforming the frontal areas of the SE-verging allochthonous Maghrebian thrust belt (Ben Avraham and Grasso, 1990, 1991; Butler et al., 1992; Grasso et al., 1995; Lentini et al., 1994; Lickorish et al., 1999; Pedley and Grasso, 1991). To the east, it is separated from the Ionian Basin by the NNW Malta Escarpment (Carbone et al., 1982; Finetti, 1982; Grasso and Lentini, 1982), which probably overprints a Mesozoic crustal fracture zone (Finetti, 1982; Scandone et al., 1981) marking the former Africa-Ionian passive margin. The escarpment developed during the Jurassic-Early Cretaceous Tethyan rifting (Robertson and Grasso, 1995) and was inverted into a mega-hinge fault system with strike-slip component during the Eurasia-Nubia plate convergence (Casero et al., 1984; Fabbri et al., 1982; Reuther et al., 1993; Scandone et al., 1981). Following the emplacement of the orogenic belt onto the Hyblean Plateau, the dextral motion accommodating the differential roll-back of the retreating Ionian slab was transferred from the Hyblean-Ionian boundary to the N-S oriented Scicli Line further to the west (Fig.2, Ben Avraham and Grasso, 1991; Grasso and Reuther, 1988; Grasso et al., 1990). Along the northern margin of the Hyblean Plateau, between the two dextral shear zones, a huge extensional deformation caused the collapse of the ENE-WSW trending Scordia-Lentini Graben (Ghisetti and Vezzani, 1980) (Fig.2). A Calabrian to Ionian sedimentary succession (1.5 to 0.9 Ma), dominated by three carbonate units, developed around the shelf margin of this graben-generated embayment (Pedley et al. 2001). In deeper low-standing areas, the Lower Pleistocene carbonates pass laterally to deep-water pelagic marls and clays. The youngest terrains of the study area are represented by Middle-Upper Pleistocene marine terraces, including Milazzian (Ionian stage; < 0.78 Ma; Cita, 2008) shallow water calcarenites and raised beaches, that crop out along the coast, carving Lower Pleistocene subaerial basaltic flows and sedimentary substratum.

The basin has been recently related to a ramp-and-flat, south-eastern dipping master fault (Catalano et al., 2010, 2011), whose hangingwall corresponds to the Siracusa Domain (**SD** in Fig. 2) (Catalano et al., 2008b).

The Late Quaternary tectonic picture of the Hyblean region was deeply modified by the propagation of the normal faults of the Siculo-Calabrian Rift Zone (**SCRZ** in Fig. 1) along the Ionian-Hyblean boundary (Catalano et al., 2008a). This process was associated to the coincident positive tectonic inversion of the margins of the Scordia-Lentini graben, along the northern border of the Hyblean Plateau, and the inversion of motion along the Scicli Line due to the restoration, in the on-shore region, of the compressive regime connected to the Nubia-Eurasia NW-SE convergence (Bousquet and Lanzafame, 2004; Catalano et al., 2011).

3. QUATERNARY TECTONICS OF THE SIRACUSA DOMAIN OF THE HYBLEAN PLATEAU

The Siracusa Domain in the eastern sector of the Hyblean Plateau, (Fig.2), is characterised by two distinct domains. In the northern sector, N50-trending faults developed along the two sides of the 12 km wide Scordia-Lentini Graben. The northern margin of the structural depression, splaying from the Scicli Line (Ghisetti and Vezzani, 1980), consists of the 40 km-long fault belt that borders the Sigona Grande-Primosole Horst (Figg. 2, 3). The fault belt includes five distinct N50 oriented, SE-dipping fault segments. They are distributed in a right-stepping en-echelon arrangement, showing length ranging from 5 to 12 km. To the south, the Scordia–Lentini Graben is bounded by a series of anastomosing NW-dipping normal faults (Pedagaggi-Agnone System; Figg. 2, 3) that extend for a length of about 27 km.

In the southern sector of the Siracusa Domain NW–SE oriented extensional faults prevail. They border two main basins: the Augusta and the Floridia Basins (Fig.2). The fault segments bordering these two tectonic depressions displace the Lower Quaternary succession (1.5–0.9 Ma) deposited along the Ionian coast (Catalano et al., 2011).

The positive tectonic inversion of the margins of the Lower Pleistocene Scordia-Lentini Graben (Bousquet and Lanzafame, 2004; Catalano et al., 2006; Romagnoli et al., 2008) is evidenced on several N70-80 oriented mesoscale fault planes by a change of the tectonic sense of motion, from extensional to contractional (see stereoplot a, b, d and e in Fig. 3). The reactivated fault planes of the northern margin of the Scordia-Lentini Graben form a 5 km-long belt, along which Lower Pleistocene volcanic horizons, at places, overthrust the Emilian calcarenites (1.5–1.2 Ma) that drape the Sigona Grande- Primosole Horst (Tortorici et al., 2006). The inversion tectonic also affected the southern margin of the Scordia–Lentini Basin (Bousquet and Lanzafame, 2004), where several N50°–70° oriented, SE-dipping (30°–40°) mesoscale reverse faults cut through the previous N60° oriented, NW-dipping extensional faults along the entire Pedagaggi-Agnone System (Fig.2). Along this fault belt, two major reverse faults, each showing a length of about 6 km and dip of about 45°, have been recognised. The kinematic analyses of these main fault planes constrain a prevalent NNW-directed compression (see stereoplot e in Fig. 3). The tectonic inversion of the extensional features is coherent with the change in the sense of motion of the Scicli Line, from right-lateral to left-lateral (see stereoplot c and f in Fig. 3).

4. LATE QUATERNARY MARINE TERRACING AND LANDSCAPE EVOLUTION

The central portion of the Siracusa Domain of the Hyblean Plateau is capped by a summit low energy-relief landscape, which consists of remnants of a mature drainage system that is now preserved at the top of the divides of deeply entrenched river valleys. The distinct isolated parts of this summit landscape, reaching a maximum elevation of about 770 m. a.s.l., outlines, as a whole, a ESE-ward dipping surface (Fig. 4).

The summit surface is bordered by a wide upper polycyclic marine terrace (Fig. 4), which is modelled on different levels of the Hyblean succession as young as the Upper Pliocene subaerial volcanics (Schmincke et al., 1997). Along the margin facing the Scordia-Lentini Graben, the polycyclic abrasion platform rests in the upper part of the slope, at an elevation of about 450 m higher than the top shallow water deposits of the basin, assigned to 0.9 Ma (Pedley et al., 2001).

Several orders of marine terraces, which are distributed along the Ionian slope, from the Floridia Basin to the southern margin of the Scordia-Lentini Graben, through the Augusta Basin (Fig. 4), undercut the upper polycyclic surface. The most complete section of the terraced paleo-shorelines is exposed in the Floridia Basin, where 11 distinct strandlines have been recognised (see profile 1 in Fig. 5). Along this section, 455 (± 90) ky-old continental deposits (Bada et al., 1991; Bianca et al., 1999), infill a karst cave which developed along the 125 m-high notch-level. Moreover, the marine terrace that is bordered by the 20 m high paleoshoreline covers coarse-grained deposits bearing relics of 117 ky-old mammals (Rhodes, 1996). According to these data, the notch-level, pre-dating the continental deposits, should be referred to the Oxygen Isotope Stage (OIS) 13 (520 ky), while the terrace, which post-dates the mammals relics, can be assigned to the **OIS** 5.3 (100 ky). Consequently, the intermediate marine terraces have to be assigned to corresponding Late Quaternary **OIS**s between the 11 (410 ky) and 5.5 (125 ky). Based on the elevation of the distinct marine terraces, a tentative correlation of the strandlines of the Floridia section with the Late Quaternary OISs is here proposed, assuming constant the uplift rate vs. time. Moving from the Floridia Basin to the northern edge of the Siracusa Domain, the two dated strandlines, as well as the rest of marine terraces, increase in elevation from 125 to 325 m and from 20 to 60 m, respectively. They form a well-defined north-eastward divergent set (Di Grande and Raimondo, 1982) coherent with the tilting of the summit surface (Fig. 6). The elevation of the marine terraces in the Floridia Basin section (profile 1 in Fig. 5) constrains an averaged uplift-rate of about 0.3 mm/y. The measured uplift-rate regularly increases to the north, varying from 0.6 mm/y in the Monti Climiti section (see profile 2 in Fig. 5), to a maximum of 0.7 mm/y at the northern edge of the plateau (see profile 3 in Fig. 5). A different distribution of the Upper Quaternary marine strandlines characterises the northern margin of the Scordia-Lentini Graben, (see profile 4 in Fig. 5). The flight of marine terraces, exposed along the Sigona Grande-Primosole Horst, at a maximum elevation of

145 m a.s.l., is composed of four orders of marine terraces, each one characterised by calcarenitic deposits assigned by Carbone et al. (1982) to the Milazzian, corresponding to the Ionian stage (0.78-0.13 Ma; Cita, 2008). The four terraces must be thus related to a pre-Tyrrhenian age. A maximum local uplift-rate of about 0.3 mm/y can be evaluated assigning the marine platforms to the OISs ranging from 13 (520 ky) to 7.3 (240 ky) (Fig. 6).

As a consequence of the proposed correlation between marine terraces and the Late Quaternary OISs, the upper polycyclic marine terrace of the Siracusa Domain must be older than 520 ky (OIS 13). The elevation of the inner edge of this platform, if related to the averaged long-term uplift rate, constrains the age of the terrace to the range from the OIS 15 (570 ky) to the OIS 21 (850 ky). This would imply that the upper marine abrasion surface is correlative with the top of the syn-tectonic deposits of the Scordia-Lentini Graben and that the summit fluvial landscape can be related to an Early Quaternary age (>850 ky) in good agreement with previous studies on the western sectors of the Hyblean Plateau (Catalano et al., 2008b).

The entire flight of marine terraces has been incised by deeply entrenched river valleys. In the eastern sectors of the Siracusa Domain (Fig. 7), they developed from the superimposition of the antecedent drainage system of the ancient summit fluvial landscape. To the north, in the upstream portion of the Anapo Valley (Fig. 7 A), the main drainage axes form a subsequent NE-directed pattern, parallel to the fault segments of the Palazzolo-Brucoli Line (see Fig. 4). In this area, the Anapo River is shifted toward the south-eastern divide, causing a clear asymmetry of the basin (block diagram in Fig. 7 A). The rest of the rejuvenated drainage system consists of resequent valleys, showing a radial pattern that dissects the summit surface.

A prevalent SE-directed consequent pattern, which captured the previous antecedent streams, characterises the terraced coastal slopes, suggesting a regional tectonic control on the youngest drainage system, coherently with the attitude of the summit surface. A morphometric picture of the fluvial basins, showing the distribution of the relief energy and the gradient vectors in the region, was obtained considering the difference between the maximum and minimum elevation measured within 1 km square cells of a grid extending on the Siracusa Domain, to the south of the Anapo River Valley. The morphometric analysis evidences that the maximum relief energy can be recognised along the ENE-WSW oriented upstream portion of the Anapo River Valley. A minor cluster of high energy relief is concentrated along the Avola Fault bounding the plateau to the south-east. Intermediate values characterise the central portion of the plateau, while the lowest estimations are located along the coastal areas and in the Floridia Basin.

5. GPS NETWORK AND DATA PROCESSING

GPS surveys were performed since 1991, across the Scordia-Lentini graben. Later on (1998 and 2000), GPS network was extended on the eastern part of the Hyblean Plateau and of the Catania-Gela foredeep (Bonforte et al., 2002). More recently, GPS measurements were carried out again on October 14 and 15 2005, during the “EUROSOT 2005” Civil Defence seismic emergency simulation, on part of the same network measured during the 1998 and 2000 surveys. Differently from the previous surveys, 24-hours measurements sessions were carried out in 2005 on some vertices of the network (on those allowing a semi-permanent installation of instrumentation without risks). Just after the late 2005 survey, new benchmarks were installed to improve the network geometry and to solve some logistic problems, in order to allow semi-permanent installations on almost all vertices. A new survey was immediately carried out (in February 2006) measuring also those stations that were not surveyed in late 2005 and the new benchmarks, in order to tie them to the old ones without losing the time series for the future. GPS data collected during the surveys are processed using Trimble Total Control software, introducing IGS final precise orbits and antenna calibration tables and keeping only fixed baselins solutions (with a ratio > 2 and rms < 2 cm), in order to achieve the maximum accuracy in the final position. The 2005-2006 measurements, due to the very short time span between them, are processed and adjusted as a unique campaign in order to achieve a stronger and more complete network solution. The measured networks are then adjusted in order to refer all station coordinates to the same frame. Following the approach used by Bonforte and Guglielmino (2008) data from ITRF stations are introduced into the processing in order to extend the network and to include and refer it to a global and well assessed reference frame; then, to isolate the local deformation from the overall plate motion affecting the entire area, the 2005-2006 survey results have been referred to the same reference frame of the 2000 one, by keeping fixed the coordinates of the external reference stations in the ITRF2000 frame at epoch 2000.4 (time of the previous survey) as reported in Bonforte et al. (2002). Station coordinates resulting from the 2000 and 2005-2006 surveys processing are then compared in order to calculate their displacements, occurred during that time period. The measured displacements are normalized to velocities (expressed in mm/y), assuming a constant motion over the 5.6 years interval between the surveys. The longer time period considered here, with respect to the 2-year interval analysed in Bonforte et al. (2002) allows stronger displacement to be cumulated and to better dilute the measurement and instrumental errors, improving the deformation/noise ratio and making more reliable the results.

6. GPS VELOCITIES AND STRAIN

The results of geodetic survey regarding the horizontal motions are summarised in Fig. 8 A as arrows, with length proportional to the velocity according to the scale, and associated 2-sigma error ellipses. The measured velocities suggest a very slow deformation of the area, in the order of a few mm/y, except for the IP13 station. These latter velocities can reasonably be imputed to site effects, as it is not coherent with data from the other surrounding stations.

Since all stations seem to be affected by a general slow westward component of motion, to achieve a better information about the horizontal deformation affecting the northern part of the Hyblean Plateau, a calculation of the distribution of the 2-D strain was performed over the area covered by the GPS network by using the routine developed by Pesci and Teza (2007). This routine allows the strain tensor distribution to be calculated on a regular grid above a geodetic network, starting from station displacements. As we are introducing station velocities, the results of the processing have to be intended as strain rates. We considered a 3 km regularly-spaced grid and the strain tensor was calculated for each node of this grid. The anomalous IP03 and IP13 velocities have been excluded from the calculation, due to the reasons previously explained and only the tensors on high and mid-significance nodes (according to the point distribution criteria established in Pesci and Teza, 2007) have been considered and reported. The results of this processing, expressed in terms of principal strain axes and contour of the areal dilatation (Fig. 8 B), evidence that two distinct domains, characterised by different strain axes, can be recognised across the northern edge of the Hyblean Plateau. To the south of the Pedagaggi-Agnone System, a very low NNW-SSE extension, producing also a small positive areal dilatation, affects the uplifted areas of the Hyblean Plateau, while in the adjacent depressed areas of the Scordia-Lentini and Simeto graben, a more significant and northward-increasing N-S contraction, producing a negative areal dilatation can be detected. In general, the strain tensor analysis evidences a very low deformation rate of the area, with maximum values of about 0.2 microstrain/year.

A NW-SE cross section (AA’ on Fig. 9 A) is also reported, in order to look at the vertical motion effectively measured at each individual station, with the associated 2-sigma error bars; from Fig. 9 the plotted vertical velocities evidence the active uplifting of the northern edge of the plateau and of the Sigona Grande-Primosole Horst, with a subsidence concentrated in the intermediate Scordia-Lentini graben. All stations inside the graben (IMTR, ISLI and ISCP) show a slight subsidence (from -1 to -3 mm/y) while all surrounding ones show uplift.

7. DISCUSSION AND CONCLUSIONS

At the northern sector of the Hyblean Plateau, the active deformation revealed by geodetic data is coherent with the Middle-Late Pleistocene tectonic picture suggested by marine terraces and drainage system. The analysed deformation history represents the last phases of the flexural tectonics of the African margin due to the Nubia-Eurasia plate convergence (Elter et al., 2003; Schmincke et al., 1997; Scribano, 1987). The progression of lithospheric flexure in the Nubia plate determined basin collapse in the forelimb of the Hyblean bulge where the Scordia-Lentini Graben developed at the hanging wall of a main south-east dipping master fault (Catalano et al., 2010). Since 850 ky, the remobilization of the southern margin of the Scordia-Lentini basin, due to a positive tectonic inversion of the Lower Quaternary extensional features (Catalano et al., 2011), produced the uplift of the eastern sectors of the Hyblean Plateau, corresponding to the Siracusa Domain. The uplift of the plateau (Pedley and Grasso, 1990; Yellin-Dror et al., 1998) has been evidenced by the staircase of marine terracing along the coastal area, that was associated with the dissection of the summit landscape. During the emergence, a set of divergent marine terraces, culminating immediately to the south of the Scordia-Lentini graben, developed as a consequence of a SE tilting of the Siracusa Domain from 850 ky to 60 ky. Also the distribution of the relief energy across the plateau seems to be influenced by the regional tilting, being the entrenchment of rivers beneath the summit landscape higher along the northern border than in the southern sector of the tilted block (Fig.7A and B). This evidence is accompanied by the diffuse capture of the antecedent rejuvenated valleys by prevalent south-east directed consequent streams. The evolution of the drainage system suggests that the regional scale tilting was active during river re-incision. The geodetic data suggest that the tilted block is bordered, to the north, by an active flexure zone (Fig.9) corresponding to the inverted southern margin of the Scordia-Lentini graben (Bousquet and Lanzafame, 2004; Catalano et al., 2010). The Middle-Late Pleistocene activity of the flexure zone is demonstrated by the difference in elevation of marine terraces between the northern border of the Siracusa Domain and the graben area. This would constrains a differential uplift rate of about 0.4 mm/y between the upper and lower inflection points of the flexure zone (Fig.9). On the other hand, GPS data reveal an active uplift, associated with extensional deformation, centred on the northern border of the Siracusa Domain in contrast with a marked contractional and subsiding domain corresponding to the Scordia Lentini graben. The inversion of GPS data evidence a NNW-directed compression that, being consistent with the available stress in situ measurements (Ragg et al., 1999) and the seismogenic stress tensor reconstructed for the region (Musumeci et al., 2005), is also fitting well the kinematics measured along the Middle-Late Pleistocene reverse faults cutting through the previous extensional fault belts (e.g. Pedagaggi-Agnone System). The geodetic stress field evidences a dominant contractional active deformation affecting the region (e.g. Mattia et al., 2012; Palano et al., 2012) with local extensional deformation which can be related to an extrados type of deformation caused by the flexuring of the northern border of the Siracusa Domain of the Hyblean Plateau. The coherence of GPS data with the Middle-Late Pleistocene morphological evidences permits to infer a long-term history of the active ground deformation that can be related to the regional compressive regime. The flexure zone, evidenced by GPS data (Fig.9), could be interpreted as the surface expression of a fault-propagation fold, active since 850 ky, related to a SSE-dipping and NNW-verging blind ramp thrust that remobilised the previous margin of the Scordia-Lentini graben. Therefore, this study demonstrates that the onshore seismicity of the Hyblean region can be confidently referred to active compressional dynamics. Furthermore, our data candidate the inferred blind thrust, located to the south of the Scordia-Lentini graben, as a major potential seismogenic source that might be considered in interpreting the historical seismicity of the region.

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Figure captions

Fig. 1 - Tectonic sketch map of the central Mediterranean from Tunisia to the Calabrian Arc, showing the main Quaternary fault belts and their relation with plate boundaries and incipient rift zones (SCRZ and PMLR). The distribution of the volcanic districts along the western flank of SCRZ is also evidenced. The inset describes the location of the Nubia-Eurasia convergent plate boundary and of the divergent western margin of Adria. Focal mechanisms are from Anderson and Jackson (1987) and Pondrelli et al. (2002-2004) and GPS velocities are from Hollestein et al., (2003) and D'Agostino and Selvaggi (2004). After Catalano et al. (2008b) modified.

Fig. 2 - Tectonic sketch map of the Hyblean Plateau (SE Sicily, see inset for location). In the figure, the border faults of the Scordia-Lentini Graben, the Scicli Line and the Malta Escarpment are evidenced. RD = Ragusa Domain; SD = Siracusa Domain. After Catalano et al. (2010) modified.

Fig. 3 - Early Pleistocene (stereonets a, b and c) vs. Middle-Late Pleistocene (stereonets d, e and f) kinematics along the main tectonic systems reported on the map of Fig. 2.

Fig. 4 - Morphotectonic and structural map of the north-eastern sector of the Hyblean Plateau with distribution of Late Quaternary marine terraces and elevation of their relative paleoshorelines, measured along the sections 1-4.

Fig. 5 – Topographic profiles showing the distribution of the marine terraces along the Ionian coast of the Hyblean Plateau. For the location of the profiles and the dating of marine terrace see Fig. 4

Fig. 6 Projection of strandlines of the marine terraces along a NW-SE oriented profile, showing the progressive tilting of the Siracusa Domain and the flexure due to the tectonic inversion of the Scordia-Lentini Basin.

Fig. 7 A - River drainage patterns of the Siracusa Domain (SD); Fig. 7B - Relief Energy map of the Hyblean Plateau showing the difference between the maximum and minimum elevation measured within 1 km^2 cell grid.

Fig. 8 A - GPS station horizontal velocities, resulting by comparing the results of the 2000 and 2005.-2006 surveys, with associates 2-sigma error ellipses. Fig. 8 B - Strain tensors and contour of the areal dilatation calculated from station velocities on a regular grid over the area.

Fig.9 - GPS vertical velocities, with associated 2-sigma error bars, projected along a NW-SE section (A-A’ dashed line in Fig. 7A) vs. the elevation of the strandlines of the marine terraces from the northern edge of the Siracusa Domain to the southern border of the Scordia-Lentini. The GPS data constrain the location of the active flexure of the northern border of the Siracusa Domain in a 8 km-narrow belt, including the southern margin of the Scordia-Lentini Graben.