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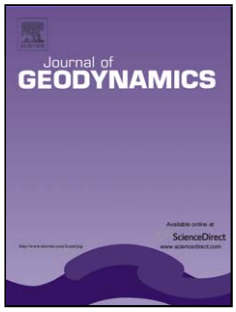

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Accurate analysis of the distribution of epicenters in Western Provence and Eastern Languedoc (Southern France)

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Abstract

The present seismicity in Western Provence and Eastern Languedoc (Southern France) is weak. However, when the historical seismicity is considered, these regions are certainly among the most seismic areas of southern France. The tectonic setting of both regions is one of an active intraplate zone. In comparatively "stable" areas like these, the study of small instrumental earthquakes ($M < 5$) is an indispensable source of information. Unfortunately, in these regions, the instrumental seismicity is, as a rule, rare and diffuse. Therefore, interpreting the spatial pattern of this seismicity through a visual inspection is a difficult and subjective process. This paper presents a quantifiable analysis of the seismicity of the study regions. Earthquakes are associated with fault zones by examining the number of epicenters per unit area. The analysis is performed through the Blade method applied on collapsed

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epicenters. The analyzed data are extracted from the Laboratoire de Détection et de Géophysique Catalog. Our analysis highlights several significant epicenter alignments associated with known tectonic features.

Key words: faults; earthquakes; epicenter alignments; France; Durance; Provence
PACS:

1 Introduction

The seismicity of southern France results from the convergence between Africa and Europe. At present, Western Provence and Eastern Languedoc are regions characterized by weak seismicity (Fig. 1). A coarse calculation (from the Richards-Dinger and Shearer's Catalog of seismicity (2000)) shows that about 170 $M \geq 2$ seismic events occur in Southern California per year and per 10^4 sq. km on average. For Western Provence and Eastern Languedoc, this seismicity rate is less than 3 $M \geq 2$ events per year and per 10^4 sq. km. However, several strong historical earthquakes (Fig. 1) have occurred in the past in these regions (Lambert et al., 1996; Levret et al., 1996). If we base the seismotectonic analysis on the historical seismicity, the study regions are certainly among the most seismic areas of France : they include about 26 % of the known

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damaging earthquakes of epicentral macroseismic intensity degree $I_0 > VII$ (Lambert et al., 1996) but cover only about 18 % of the country's surface. This point is also supported by indications of Quaternary deformation induced by destructive earthquakes (Ghafiri, 1995; Sébrier et al., 1997). In this environment, in terms of seismic hazard assessment, the identification of the faults that have ruptured during these destructive events is of the utmost importance and is still under debate (Cushing et al., 1997; Lacassin et al., 1998; Sébrier et al., 1998; Baroux et al., 2003).

GPS quantification of the deformation in the study regions or close to them (in the Southern Alps) shows that present displacement rates are very small (Calais et al., 2000; Nocquet, 2002; Nocquet and Calais, 2004). Thus, the geodetic information seems to be consistent with the present day weak seismicity. In such an environment, due to the absence of a clear tectonic signal, the commonly used techniques for seismic hazard assessment are not easily practicable. Despite the difficulty, some of these techniques have been applied with success in Provence (Carbon, 1996; Peulvast et al., 1999; Schlupp et al., 2001; Baroux et al., 2001, 2003). It is nevertheless a fact that efforts should be taken to optimally use all the available sources of information. In comparatively "stable" areas like these, the most conspicuous information concerning active tectonics certainly comes from the study of small earthquakes ($M < 5$) (Amorèse et al., 1999). Unfortunately, in these regions, due to the "quiet" tectonic conditions

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and/or the sparsity of the seismic networks, the instrumental seismicity is, as a rule, rare and diffuse. Thus, in "stable" areas, analyzing the seismicity distribution and associating earthquakes with faults are not straightforward processes. This kind of analysis can be performed through mathematical methods. Nevertheless, until now, there have been no systematic (quantifiable) analysis of the distribution of the seismicity of Western Provence and Eastern Languedoc. Here, we analyse the spatial distribution of the instrumental seismicity and its relations with known faults or fault zones through the mathematical approach of the Blade Method (Amorèse et al., 1999). This method is applied on the instrumental seismicity of the studied regions. As the seismicity of each of these "relatively quiet" regions is sparse and diffuse, this kind of mathematical analysis will fail to identify single seismogenic faults. Nevertheless, this approach can help in the detection of active fault zones. Moreover, through the Blade Method, the "activity" of these fault zones can be somewhat quantified. The Blade Method (Amorèse et al., 1999) has previously been applied with success both on epicentral data from Normandy (Northwestern France) (Amorèse et al., 1999) and Central United States (Amorèse, 2003). The method has been tested on the seismicity of the San Francisco Bay area in California (Amorèse et al., 1999). This is not a push-button technique: the Blade Method is not self-sufficient. Because random epicenter alignments are still possible, computations issued from the Blade Method should be checked. Indeed, in

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order to discard any false fault zone detection, the method requires knowing the structural pattern of each study region. This information is available: the structural pattern of Eastern Provence and Western Languedoc has been well-known for many years (Grellet et al., 1993).

2 Tectonic setting

The main geological structures of the study regions are due to the two last tectonic events: the Pyrenean (Late Cretaceous to Late Eocene, about 70-40 Ma) and Alpine (Miocene to present) tectonic phases. From West to East, three main NNE-SSW faults are observed: the Cévennes, the Nîmes and the Durance faults (Fig. 1). Another, smaller fault zone, is the N-S Salon-Cavaillon fault system (Fig. 1). This smaller fault is of special interest because it is known to have been active during Quaternary times (Molliex et al., 2007). All these structures have been associated with the evolution of the passive margin of the Tethys during the Early Jurassic. The study regions are under a N-S compression (Combes, 1984; Rebai et al., 1992; Baroux et al., 2001) and some evidence exists to support the fact that the NNE-SSW and the E-W structures are being reactivated by the present-day stress field (Dubois, 1966).

The Cévennes fault is a 180 km-long NE-SW striking fault (Fig. 1). The possible activity of this structure (mainly in-

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ferred from satellite images (Lacassin et al., 1998)) is clearly debatable (Lacassin et al., 1998; Sébrier et al., 1998; Baize et al., 2002).

Several authors consider the Nîmes fault as active (Combes et al., 1993; Baroux, 2000). However, the activity of the Nîmes fault is not unanimously accepted (Mattauer, 2002). Several major historical earthquakes could be associated with the Nîmes fault (Schlupp et al., 2001) : epicenters are mainly located West of Avignon and in the Châteauneuf - du - Pape area (Fig. 1). The Nîmes fault is extended in depth by a listric fault dipping to the SE (Benedicto et al., 1996; Schlupp et al., 2001). Its orientation (it strikes N50° and dips 60° southward) is such that a N-S compression would appear to favor left-lateral strike-slip motion with a possible reverse component (Schlupp et al., 2001).

The Durance fault is considered as active by various authors (Combes et al., 1993; Cushing et al., 1997; Baroux, 2000; Cushing et al., 2007). The Durance fault is a sinistral strike-slip fault (Combes et al., 1993) dipping to the NW. Although the historical seismicity is regular in this area (on average, one event of magnitude 5-5.5 per century (Volant et al., 2003)), at present, the seismicity of the region of the Durance fault is very low. Epicenters of historical earthquakes are mainly located above the Manosque anticline (Peulvast et al., 1999). In the Durance region, from North to South, several E-W compressive fold zones may be possible sources of earthquakes. These fold zones are : (1) the Mont Ventoux-Montagne de

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Lure, (2) the Lubéron zone and (3) the Costes-Trévaresse fold zones. The N110° Trévaresse thrust fault is responsible for the June 11, 1909 Lambesc lethal earthquake (Levret et al., 1986; Lacassin et al., 2001; Baroux et al., 2003).

The Salon-Cavaillon fault system (SCFS) is a 20-km long N-S corridor where recent low deformation is suspected (Peulvast et al., 1999). It is proposed (Peulvast et al., 1999) that subsidence occurs in the west, along the northern part of the Salon-Cavaillon fault system. This subsidence could be partly responsible for the diversion of the lower Durance towards the Rhône river (Peulvast et al., 1999). Otherwise, uplift is well known to occur along the 20-km long northern extension of the SCFS (Fourniguet, 1987; Peulvast et al., 1999).

3 Method

Since years, many mathematical methods have been developped to associate seismicity with faults (Suzuki and Suzuki, 1965, 1966; Vere-Jones, 1978; Kagan and Knopoff, 1981; Fehler et al., 1987; Frohlich and Davis, 1990; Tosi et al., 1994; Chapman et al., 1997; Amorèse et al., 1999; Gaillot et al., 2002; Amorèse, 2003; Wesson et al., 2003). In this study, the seismicity of western Provence and eastern Languedoc is analysed through the Blade Method (Amorèse et al., 1999) combined with an improved version of the Best Estimate Method (Bossu, 2000). This new combined approach has previously

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been applied with success on the seismicity of southern Illinois and southeastern Missouri (Amorèse, 2003). Through this kind of analysis based on instrumental seismicity, our purpose is to highlight the most significant seismolineaments, indicating seismogenic structures. It is noteworthy that the Blade Method does not include information from focal mechanisms in the analysis. From this viewpoint, the Blade Method may be less convincing than the method proposed by Chapman et al. (1997) in their statistical analysis of the seismicity in the Eastern Tennessee Seismic Zone. Unfortunately, in Western Provence and Eastern Languedoc, very few well-constrained focal mechanism solutions have been previously determined in the vicinity of the known major tectonic features (Baroux et al., 2001). Thus, in our study, focal mechanisms are not primary sources of information and are only used to check our results. Hereafter, we present a summary of our methodology (for more details, refer to Amorèse et al (1999), Bossu (2000) and Amorèse (2003)).

The Blade Method analyses the number of epicenters per unit area. Each epicenter is the center of rotation of a blade (Fig. 2). The rotation of each blade is incremental. The value of the angular increment depends on the desired angular resolution and on the geometry (length, width) of the rotating blade, in order to investigate the whole circular area. The length of the blade controls the sensitivity of the method to short- or long-range anisotropies in the point (epicenter) pattern. Therefore, the choice of this value is dependent on the

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lengths of the faults of the study zone (Fig. 3). The uncertainties of the epicenter location are taken into account through the width of the blades. The suitable value for the blade width is about twice the mean uncertainty of the epicenter location (Amorèse et al., 1999). For each blade position, the number of observed points within the blade is determined and compared with the number of points within the circular zone. Tests of significance, based on binomial distributions, are performed. The Blade Method is applied on epicentral locations: the association of earthquakes with faults is based on the key assumption that faults are steeply dipping faults or that seismicity is very shallow. This point is another argument to use blades rather than lines in the detection process. The aim of the Blade Method is not the detection of strictly linear features because investigated points are supposed to be projected points from dipping fault planes, that, moreover, are not necessarily strict planar structures.

Another difficulty arises from a possible inhomogeneous distribution of epicenters along each blade. In order to reduce the influence of pointlike seismic nests, epicentral data analysed through the Blade Method should be previously filtered. In this study, the filtering process is achieved through a epicenter collapsing method: the Best Estimate Method (Bossu, 2000). Moreover, this approach reduces the effect of random location uncertainties (Bossu, 2000). The procedure of the Best Estimate Method is as follows (Bossu, 2000): a) for each event i, the list of earthquakes whose initial locations fall

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within its location uncertainty is determined; (b) the new pseudo-location for i is then given by the centroid of all these earthquakes; (c) steps (a) and (b) are repeated for all hypocentres of the studied area. In this study, as in that by Amorèse (2003), we do not use the original Best Estimate Method, but a modified version of this technique. Indeed, the original version of the Best Estimate Method is biased when very badly located events are merged with well located events (Amorèse, 2003). Once this filtering is done, the homogeneity of the epicenter distribution along each blade is checked via mean and standard deviation calculations. When mean and standard deviation measurements of epicenter locations seem not to be consistent with a uniform point distribution, the corresponding blade is discarded (Amorèse et al., 1999).

The Blade Method is based on the hypothesis that, even during the interseismic phase of the earthquake cycle, microseismicity, though weak, is not randomly distributed and is still localized along major faults zones. It is not an obvious fact; nevertheless the best example of this kind of seismic pattern is certainly provided by the seismicity that occurred prior to the Ms=7.1 Loma Prieta earthquake of October 17, 1989 in California. The epicentral area of the mainshock was not a microseism-free region before the earthquake occurrence (Fig. 4 and Dietz and Ellsworth (1997), Fig. 3). Thus, although the Blade method cannot be successful in the detection of perfectly locked (perfectly "aseismic") patches of faults, it seems that it does not fail in the detection of possibly active

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fault zones when the seismic activity is weak and diffuse. One should bear in mind that the Blade method is a low resolution technique that cannot exactly identify active segments of a given fault, if these segments are "short" and/or behave in a perfectly "aseismic" manner.

4 Data and parameters of the computations

The area of investigation includes the western part of Provence and eastern part of Languedoc between 43° N and 45° N and 1° E and 6.5° E (Fig. 1). The input data are 1634 epicenters (magnitudes are ranging from ML=1 to ML=5.3) determined in this zone between 1962 and 2005 by the seismic network of the Laboratoire de Détection et de Géophysique (LDG/DASE/CEA). Superimposed onto background seismicity, five large clusters are discernible in the Aubrac plateau, near Montélimar city, in the Extern Alps (Haute Provence), offshore east of Marseille and in the Espinouse mount (Fig. 1). From the 1634 events, 138 are discarded because they are provided without ML magnitude information. Thus, what is hereafter termed the 'raw data set' includes 1496 epicenters. Data features and the best parameters for applying the Blade Method are interdependent:

(1) The maximum uncertainty of epicenter location is the value that controls the width of the rotating blades (Amorèse et al., 1999; Amorèse, 2003).

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(2) The length of the blades is controled by the length distribution of the regional faults (Amorèse et al., 1999; Amorèse, 2003).

In other respects, rotating blades are expected to show a length-to-width ratio in agreement with the elongated map view of a fault. When the Blade Method has been used in previous studies (Amorèse et al., 1999; Amorèse, 2003), the length-to-width ratio of the blades was always greater than 3:1.

In this study, in order to search for seismic features of different lengths, the Blade Method has been applied twice. Once the method has been performed by using (1) a 0.01 significance level, (2) a 35 km long diameter for each circular zone, (3) 12 km wide blades (this value is consistent with the 3:1 length-to-width ratio of rotating blades) and (4), in order to offer a sufficient angular resolution, a 10 ° wide rotation angular increment. This first application of the Blade Method is in tune with the detection of the regional faults presented in Figure 1, whose lengths are illustrated in Figure 3: the blade length (35 km) is consistent with the mean value of the lengths of the regional faults (32 km). Events with the major axis of the 90 % confidence ellipse larger than 6 km are discarded from our raw data set. Thus, 1011 event locations are kept, which correspond to a 32 % reduction in the number of events in the raw data set. Finally, from these 1011 events, our modified version of the Best Estimate Method determines

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873 pseudo-locations (Fig. 5).

The method is also performed by using a 70 km long diameter (the other parameters being kept unchanged). In this case, the search is for longer seismic features.

5 Results

In the study region, several seismolineaments are highligthed by the combined use of the Best Estimate Method and Blade Method. Results are presented in Figures 5 to 10 and Table 1. Our attention is first drawn to alignments in connection with a previously recognized fault or fault zone.

In the Aubrac plateau area, no significant epicenter alignment is detected (Fig. 6).

In the Montélimar area, the northern end of the Cévennes fault is highlighted by the Blade Method as well as the N-S Villefort fault (Figs. 7a and 7b). Illustrated by a smaller type I error probability value (Table 1), the Villefort seismolineament is more clearly detected by a 35-km long blade than by a 70-km long one. This is not true for the northern part of the Cévennes fault: this seismolineament (North of the town of Barjac, Fig. 7b) is better highlighted by the longer blade (the p-value is $3.156\ 10^{-6}$ for the 70-km long blade, Table 1). Close to the town of Montélimar, the seismic area of Clansayes is outlined by both instrumental and historical seismicity (Fig. 7a). However, no correlation is recognized between this seis-

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micity and any mapped fault surface trace.

The Blade Method does not associate the Mont Ventoux-Montagne de Lure, the Lubéron zone and the Costes fold zone with any significant instrumental seismicity (Figs 8a and 8b). On the contrary, the Durance Fault is clearly highligthed by N20° blades (Figs. 8a and 8b). This is especially true for the southern blades that show the smallest values of probabilities (Table 1). Moreover, the detected seismolineament coincides with the distribution of the historical macroseismic epicenters (Lambert et al., 1996) located near Volx, Manosque, Beaumont-de-Pertuis and Mimet (Figs. 8a and 8b). Besides, this result is perfectly in agreement with the distribution of the seismicity located by the IRSN (Institute for Radioprotection and Nuclear Safety) Durance local seismic network (Cushing et al., 2007). Indeed, this study (Cushing et al., 2007) shows an high density of earthquakes along the N20° #9 fault segment (Cushing et al., 2007, Figure 5). In the Durance Fault area, our results are also consistent with the geometries of the fault-plane solutions that have been determined by Volant et al (2000), close to the main fault trace (Figs. 8a and 8b).

In the Salon-Cavaillon Fault System area (Fig. 9), the Nîmes fault is not detected as a seismolineament by the Blade Method. In this area, the only detected significant feature is the westernmost N-S Salon-Cavaillon Fault (Fig. 9). The Blade Method detects the seismolineament along the western edge of this fault (Fig. 9). This is in agreement with the westerly dip of

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the fault (Peulvast et al., 1999). The locations of historical macroseismic epicenters near L'Isle-sur-la-Sorgue and Cavaillon (Lambert et al., 1996) are consistent with the result of the Blade Method (Fig. 9).

In the Espinouse mount area, a N150° epicenter line is visible and detected near Corneilhan; nevertheless, as we argue from our reference tectonic map, no significant seismolineament is detected (Fig. 10). In this area, as illustrated by the rose diagrams (Fig. 10), blades tends to straddle faults that are perpendicular to them.

6 Conclusions

Our results should be interpreted cautiously while bearing in mind two intrinsic methodological limitations :

(1) The analysis is based on instrumental seismicity. It depends on the capabilities of the recording seismic network both in terms of detection thresholds and location uncertainties. The spatial density of seismic stations is the parameter controling these points.

(2) The analysis depends on the relevancy of the tectonic map that is used as the reference document.

Moreover, the spatial resolution is limited by the scale of analysis. It depends on the lengths of blades and investigated faults. In our analysis, small faults (cartographic length

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shorter than 35 km) are underestimated as they are not considered as possible individual seismic sources. In spite of these drawbacks, our study shows that, even when the seismicity is poor, the spatial distribution of epicenters always carries useful information. In our approach, the previously mentionned influence of location uncertainties is weakened by considering collapsed pseudo-locations instead of raw epicenter locations. Despite the "bad" seismotectonic conditions of the study region, our analysis reveals that several known major tectonic features in Western Provence and Eastern Languedoc can be associated with a significant instrumental seismicity.

Of course, when it happens that instrumental seismicity is not associated with a given fault by the Blade Method, this does not mean that this fault is aseismic : in tectonic domains where deformation rates are very small, the recurrence interval of significant seismic events exceeds the time span covered by instrumental records. Our analysis reveals that in the Aubrac plateau area, in the Espinouse mount area or in the Nîmes fault area, the instrumental seismicity seems to be more randomly distributed than associated with a known major fault.

On the contrary, the northern part of the Cévennes fault, the Durance fault and the Salon-Cavaillon fault zone are marked by epicenters whose alignments are statistically significant. The Blade Method also higlights the Villefort fault. This result is unexpected because, due to the lack of a strong historical earthquake in its vicinity, this fault is usually not consid-

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ered as an important structure in seismotectonic studies of Provence. Our analysis suggests that thorough investigations in the Villefort area might be fruitful in better estimating the regional seismic hazard.

Our analysis is better than simply checking the instrumental seismicity on each known tectonic feature, because it provides quantitative values (the type I error probability values). Thus, our procedure enables comparisons to be made within results. It appears that the more convincing seismolineaments (i. e. the seismolineaments that shows the smallest type I error p-values) are associated with :

(1) the 70 km long Cévennes blade ($p = 3.156\ 10^{-6}$)
(2) the 35 km long Durance southern blade, in the area of Mimet ($p < 10^{-9}$)
(3) the 35 km long Villefort blade ($p = 2.945\ 10^{-6}$).

Because the Blade Method does not give information on the kinematics of faults, it is far beyond the scope of this study to discuss the geodynamic setting of Western Provence and Eastern Languedoc. Moreover, as accurately stated by Sébrier et al. 1998, the correct assessment of the seismic hazard in a weak deforming region implies a multidisciplinary approach. Consequently, our study contributes to the understanding of the seismotectonic conditions of Western Provence and Eastern Languedoc, but it should be complemented by data from other tectonic, geomorphological or geophysical studies to establish conclusive results about the regional seismic hazard.

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Seismolineament	Blade length and location	p-value
Villefort	35 km	$2.945\ 10^{-6}$
	70 km	$7.075\ 10^{-5}$
Cévennes	35 km	$6.393\ 10^{-3}$
	70 km	$3.156\ 10^{-6}$
Durance	35 km, northern blade	$7.249\ 10^{-3}$
	35 km, central blade	$3.585\ 10^{-3}$
	35 km, southern blade	$10^{-9} <$
	70 km, northern blade	$4.904\ 10^{-3}$
	70 km, southern blade	$3.072\ 10^{-6}$
Salon-Cavaillon	35 km	$3.585\ 10^{-3}$

Table 1

Probabilities of the type I error for each blade of a detected seismolineament. A type I error occurs when one rejects the null hypothesis when it is true. In the Blade Method, the null hypothesis is that the observed number of points in the blade is the result of Bernoulli trials (Amorèse et al., 1999).

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Fig. 1. Tectonic sketch of the study regions showing (A) historical (Lambert et al., 1996) and (B) instrumental (LDG-CEA, 1962-2005) seismicity. Five seismicity clusters (sc1, sc2, sc3, sc4, sc5) are visible in the present seismicity. The abbreviation SCFS stands for Salon-Cavaillon Fault System, Hte Prov. corresponds to Haute Provence, Ch.-du-Pape stands for Châteauneuf-du-Pape. Faults are drawn from the seismotectonic map of France at 1/1 000 000 (Grellet et al., 1993)

Fig. 2. Explanatory sketch of the Blade method. Each point is an epicenter. An incrementally rotating blade (dashed line) is investigating a circular zone (dotted line) around each epicenter. The number of epicenters inside each blade is counted and compared with the number of epicenters inside the disk.

Fig. 3. The length distribution of regional faults in the study regions. The faults used to draw this diagram are those displayed in Figure 1.

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Fig. 4. Maps showing the M $\geq$ 1.0 seismicity in the 1989 Loma Prieta earthquake region before the mainshock occurrence (January 1, 1979, through October 17, 1989). Data are from the Northern California Earthquake Catalog. Star marks the epicenter of the Ms=7.1 mainshock initiated at 00:04:15.28 UTC on October 18, 1989 (Dietz and Ellsworth, 1997). a) Epicenters of all the M $\geq$1.0 events (8770) and b) epicenters of the best M $\geq$ 1.0 located events (4174). The selected hypocenters have root mean square residual (RMS) $<$ 0.1 s, number of P and S times with final weights greater than 0.1 $\geq$ 24, horizontal standard error (ERH) $<$ 1.0 km and vertical standard error (ERZ) $<$ 2.0 km. The maps show that several epicenters fall in the area around the mainshock (star): during the interseismic phase of the earthquake cycle, "aseismicity" is not complete. b) shows the result of the Blade Method (0.01 significance level, 40x4 km blades, 10° wide rotation angular increment) on the best located events. Close to the Loma Prieta mainshock area, the microseismicity distribution is consistent with a NW-SE fault zone: the Blade Method can be successful even during the interseismic phase of the earthquake cycle.

Fig. 5. Map showing the results of the Blade Method applied to the instrumental seismicity of the studied regions. Boxes identify the zones that are zoomed in Figures 6 to 10. Blades are 35 km long and 12 km wide. The small circles are the 873 investigated earthquake pseudo-locations.

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Fig. 6. Map showing the results of the Blade Method in the Aubrac plateau area (35 x 12 km blades).The small circles are the earthquake pseudo-locations. Rose diagrams show the strikes of the faults and of the blades.

Fig. 7. Maps showing the results of the Blade Method in the Montélimar area. Blades filled by patterns can be sensibly associated with a known fault (they are close and parallel or sub–parallel to a known fault). Unfilled blades are not easily associable with a previously recognized fault zone. The small circles are the earthquake pseudo-locations. The squares are the historical earthquakes macroseismic epicenters (Lambert et al., 1996). a) 35 x 12 km and b) 70 x 12 km blades.

Fig. 8. Maps showing the results of the Blade Method in the Durance fault area. a) 35 x 12 km and b) 70 x 12 km blades. The focal solutions (lower hemisphere) of two $M_L = 2.9$ seismic events are from Volant et al. (2000). The date is labelled at the solutions (format yymmdd). The rest of the legend is the same as in Figure 7.

Fig. 9. Map showing the results of the Blade Method in the Salon-Cavaillon fault system area (35 x 12 km blades). The rest of the legend is the same as in Figure 7.

Fig. 10. Map showing the results of the Blade Method in the Espinouse mount area (35 x 12 km blades). The small circles are the earthquake pseudo-locations.

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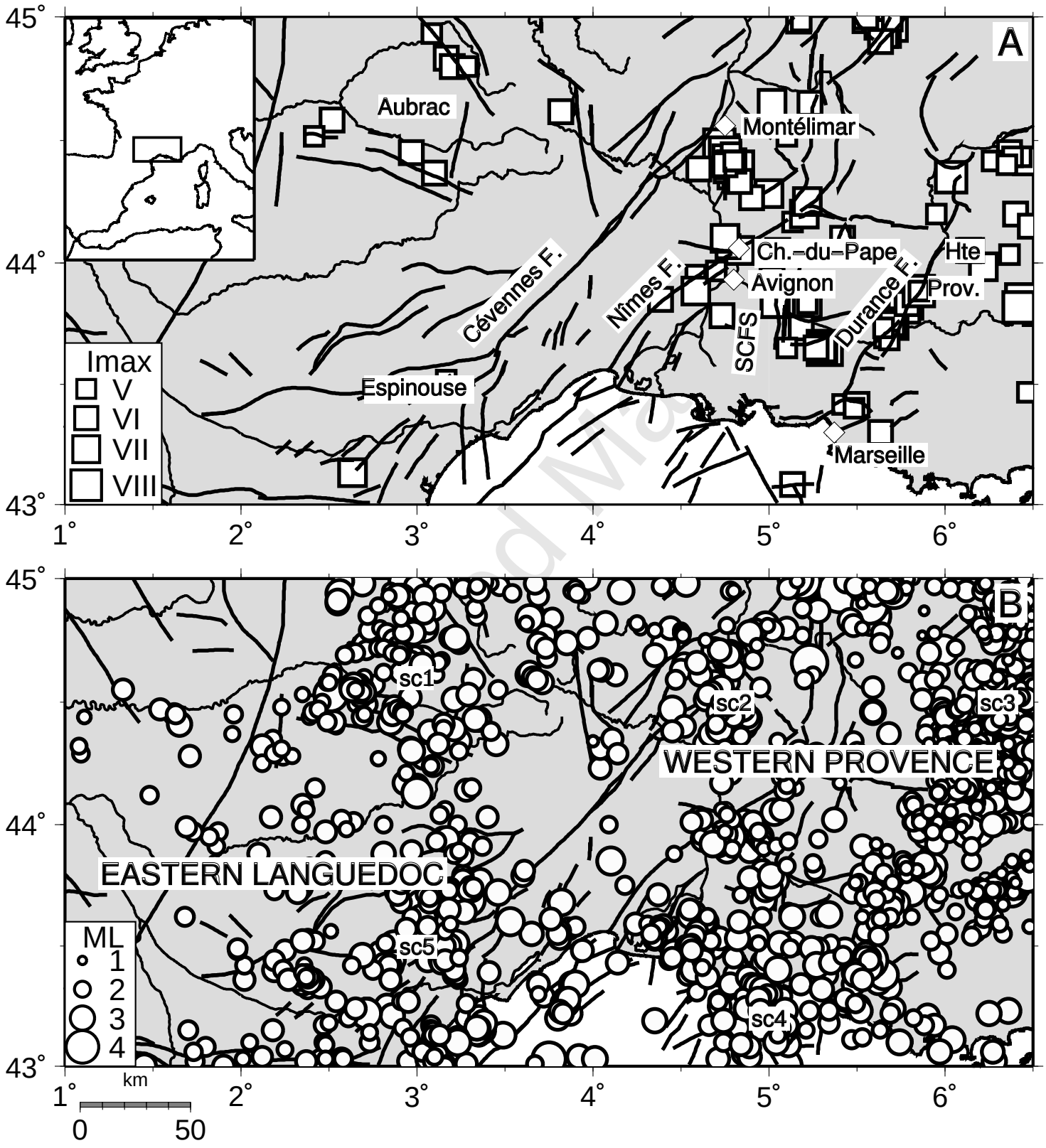

Figure 2, Explanatory sketch

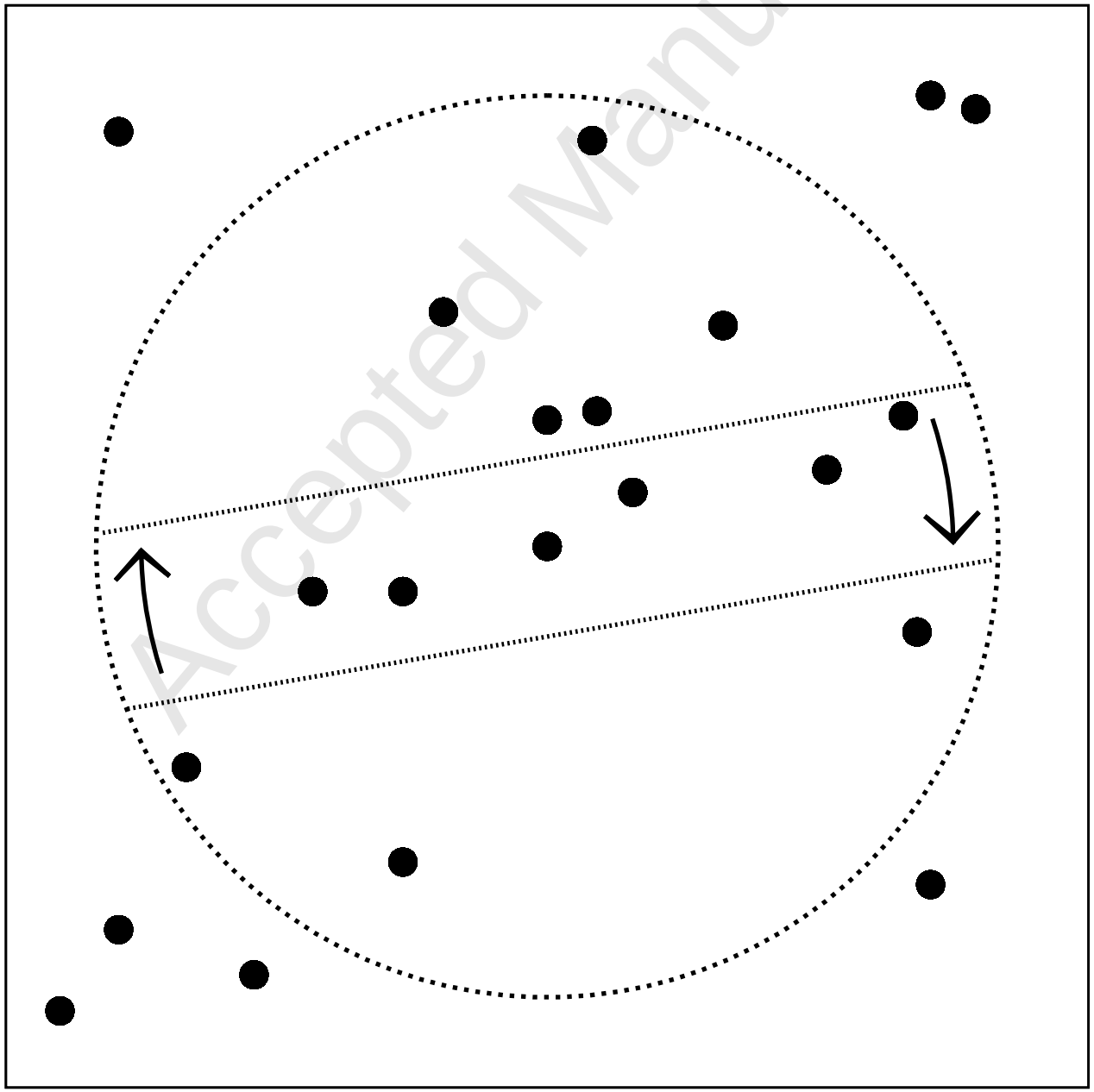

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Figure 3, length distribution

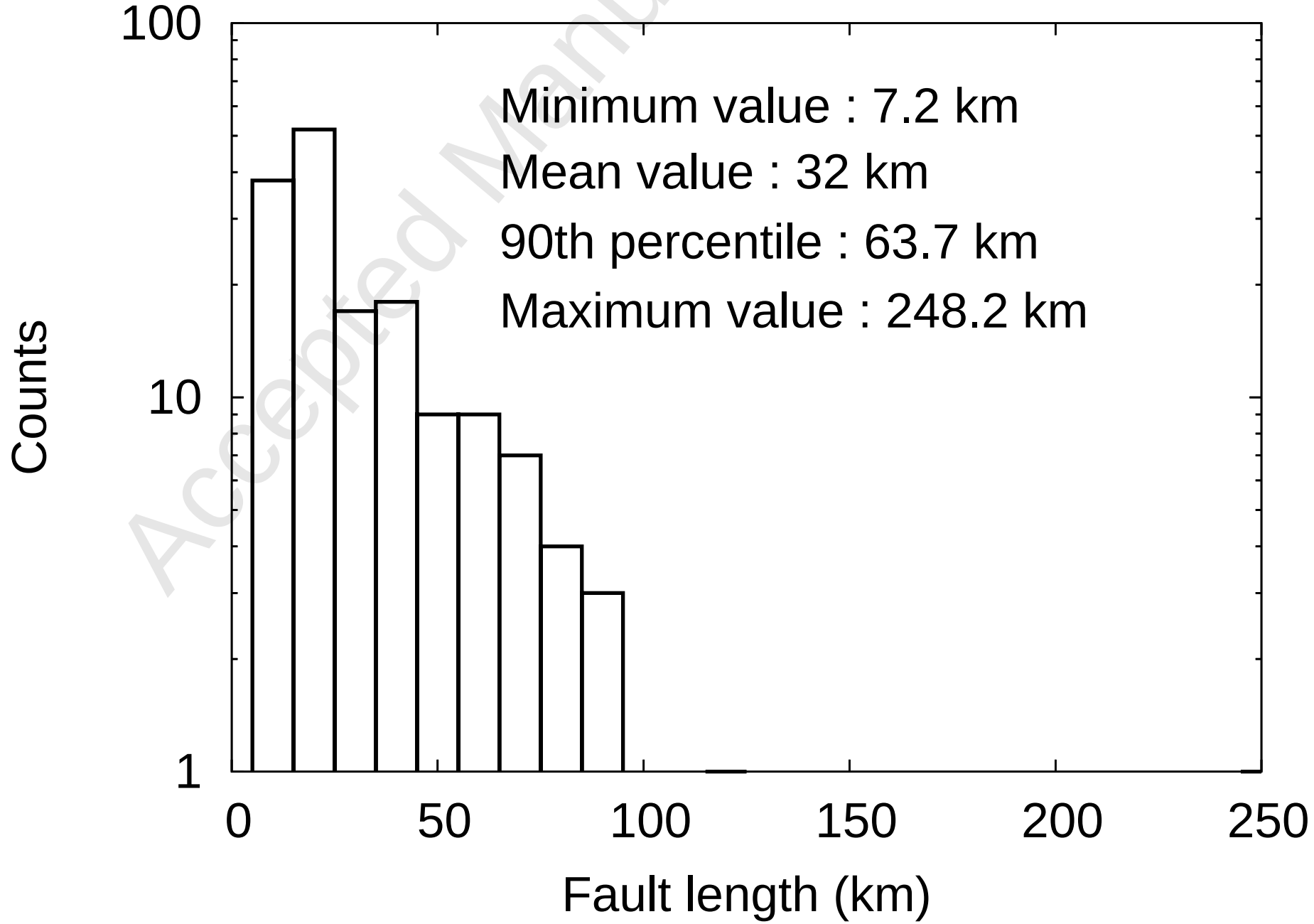

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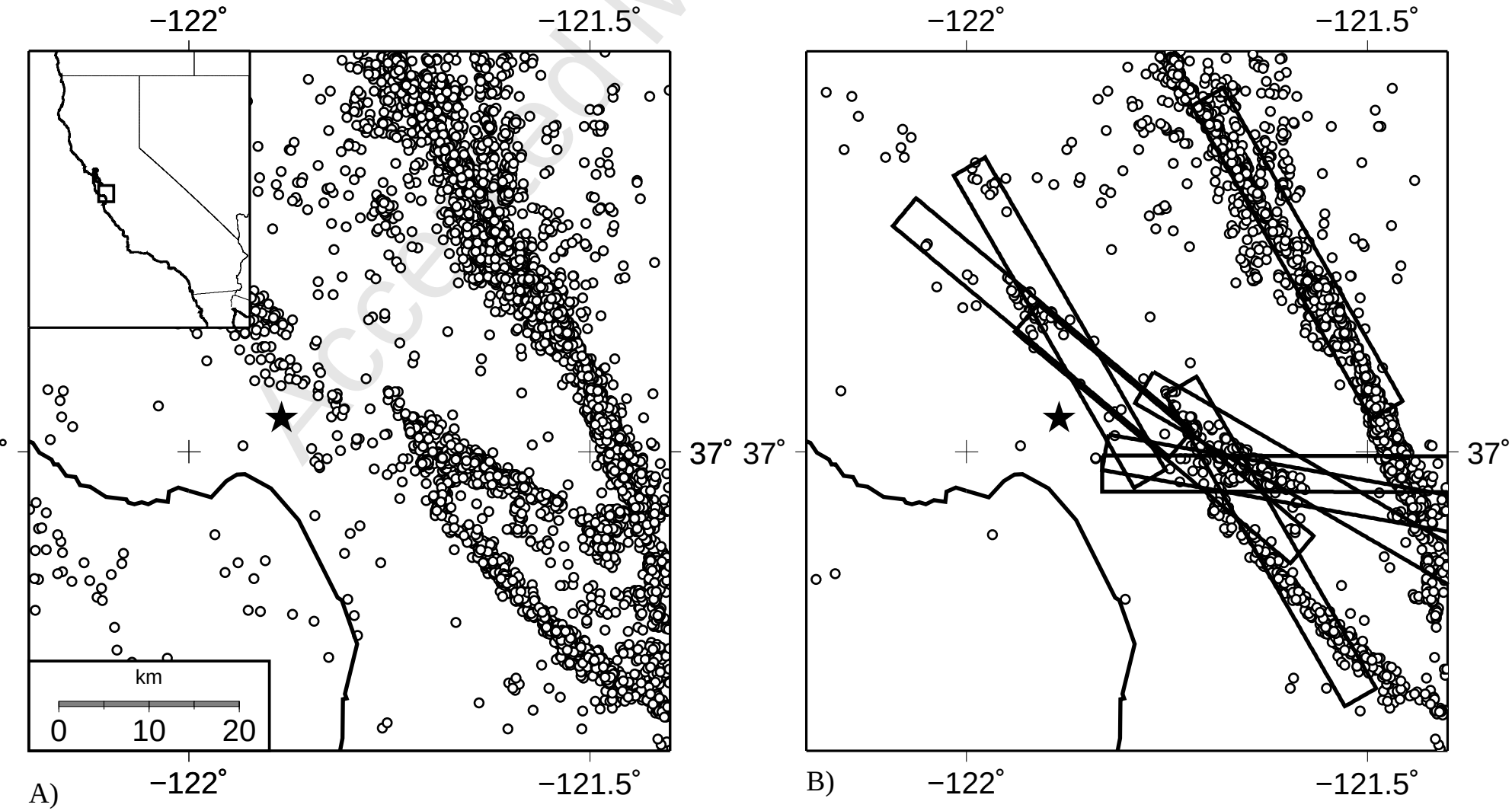
Figure 4. maps California



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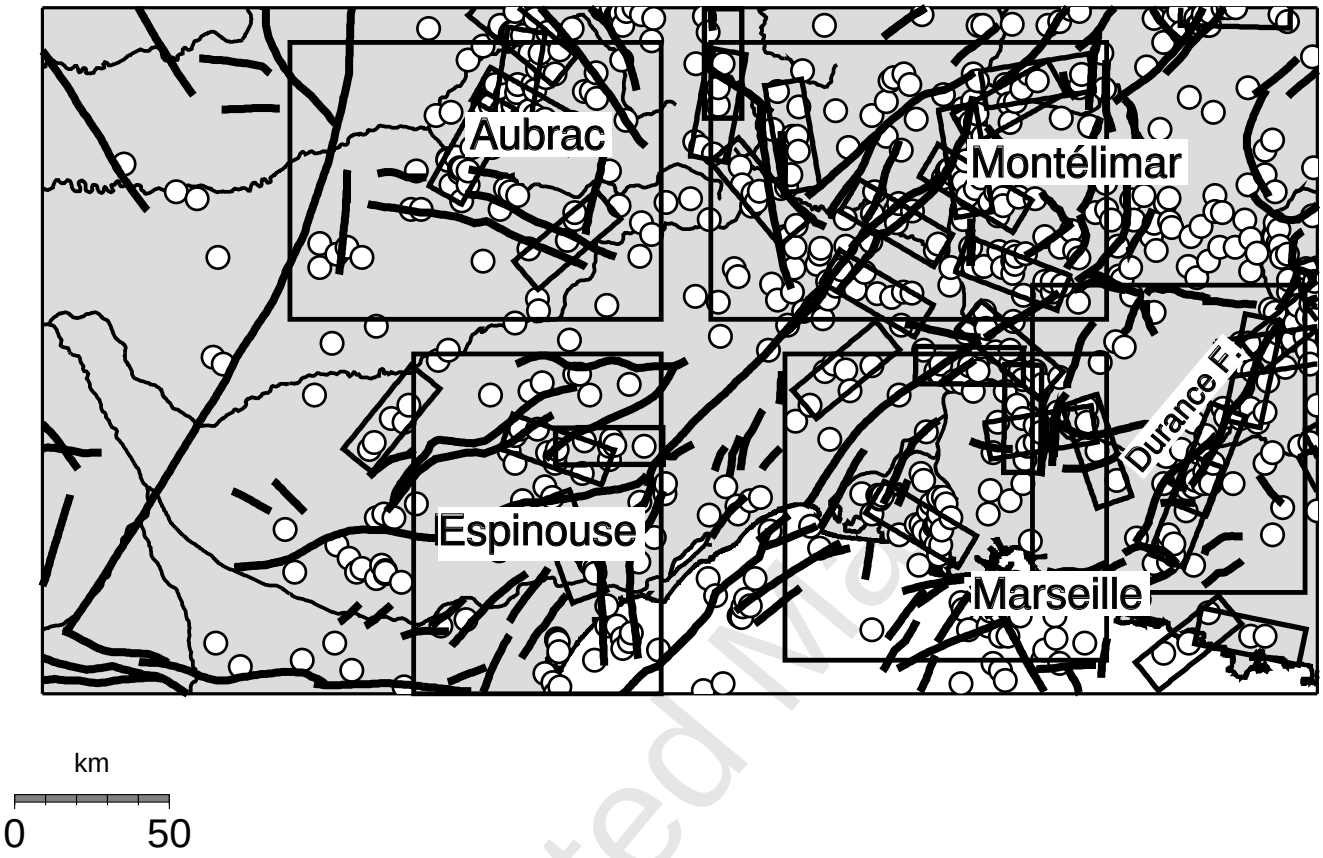

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Figure 6. map Aubrac

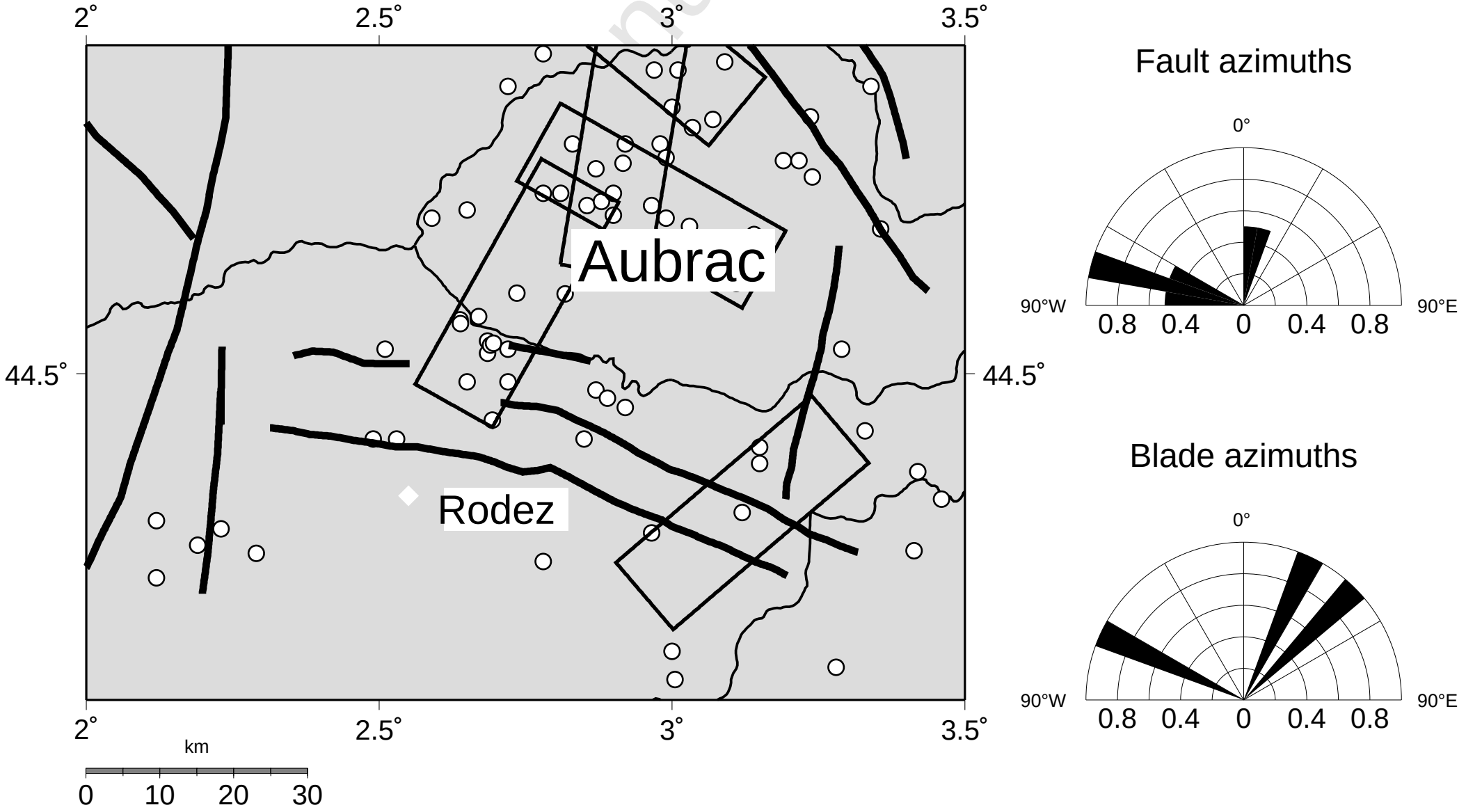


Figure 7. part A map Montelimar

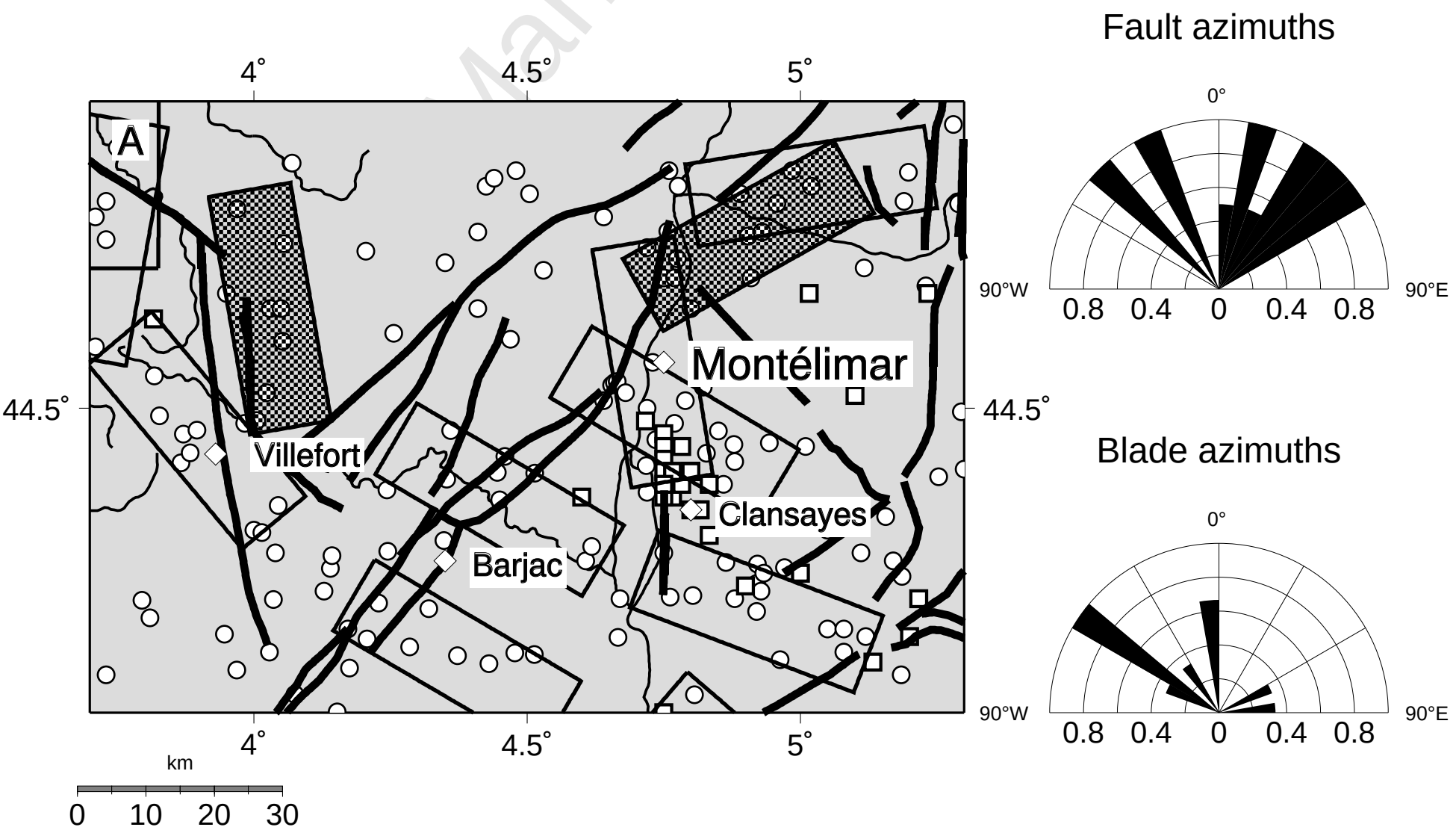


Figure 7. part B map Montelimar

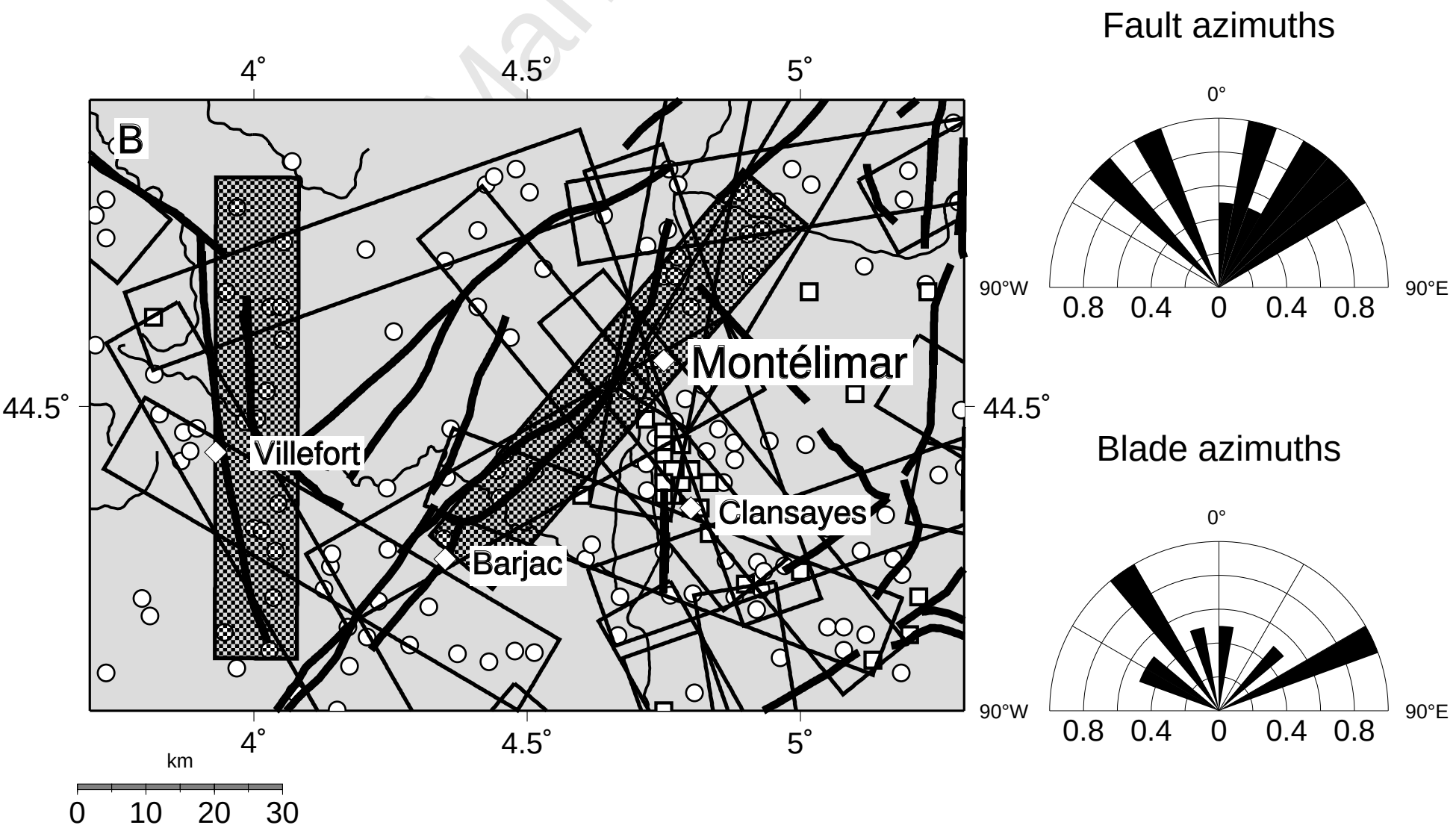
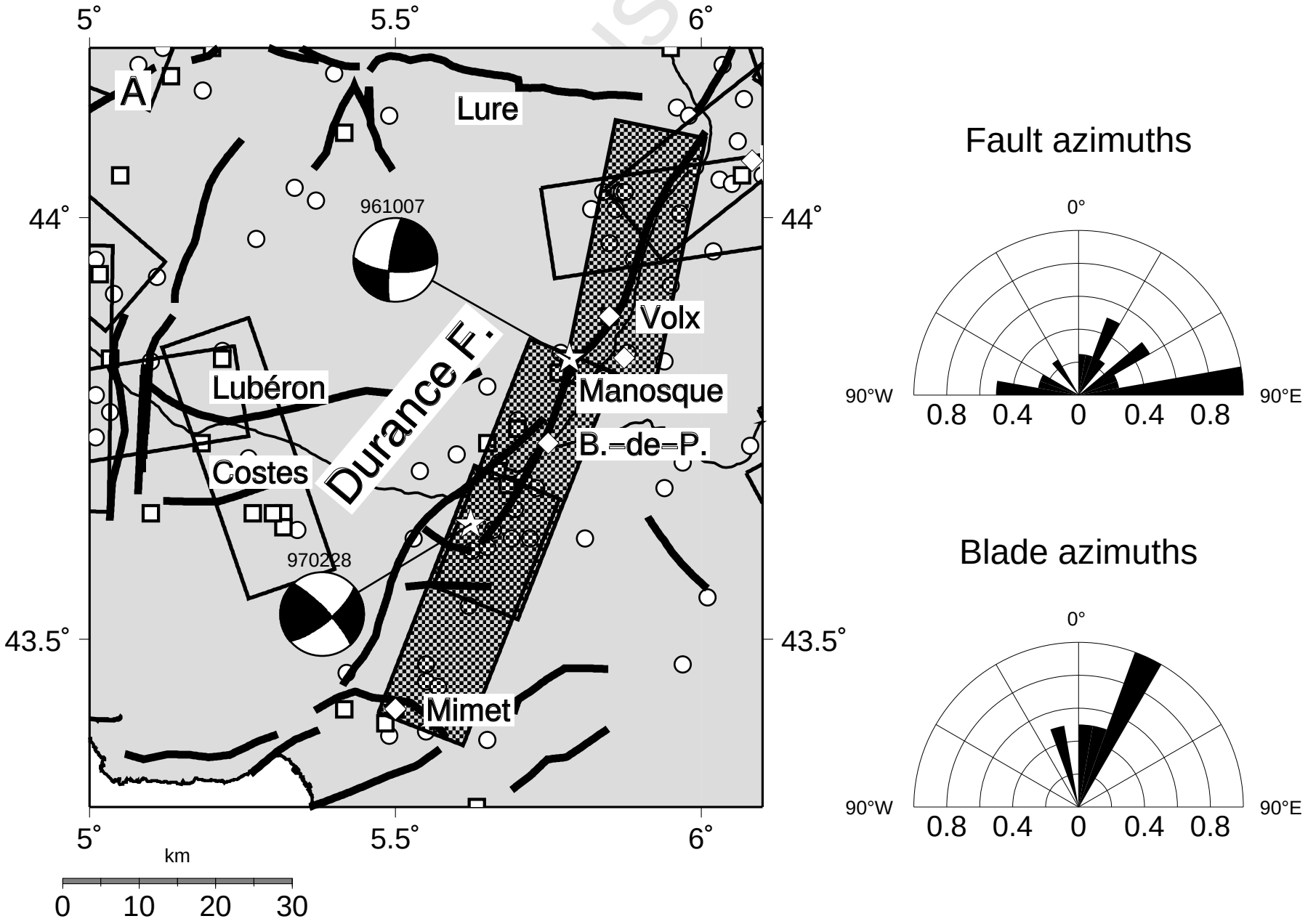


Figure 8. part A map Durance



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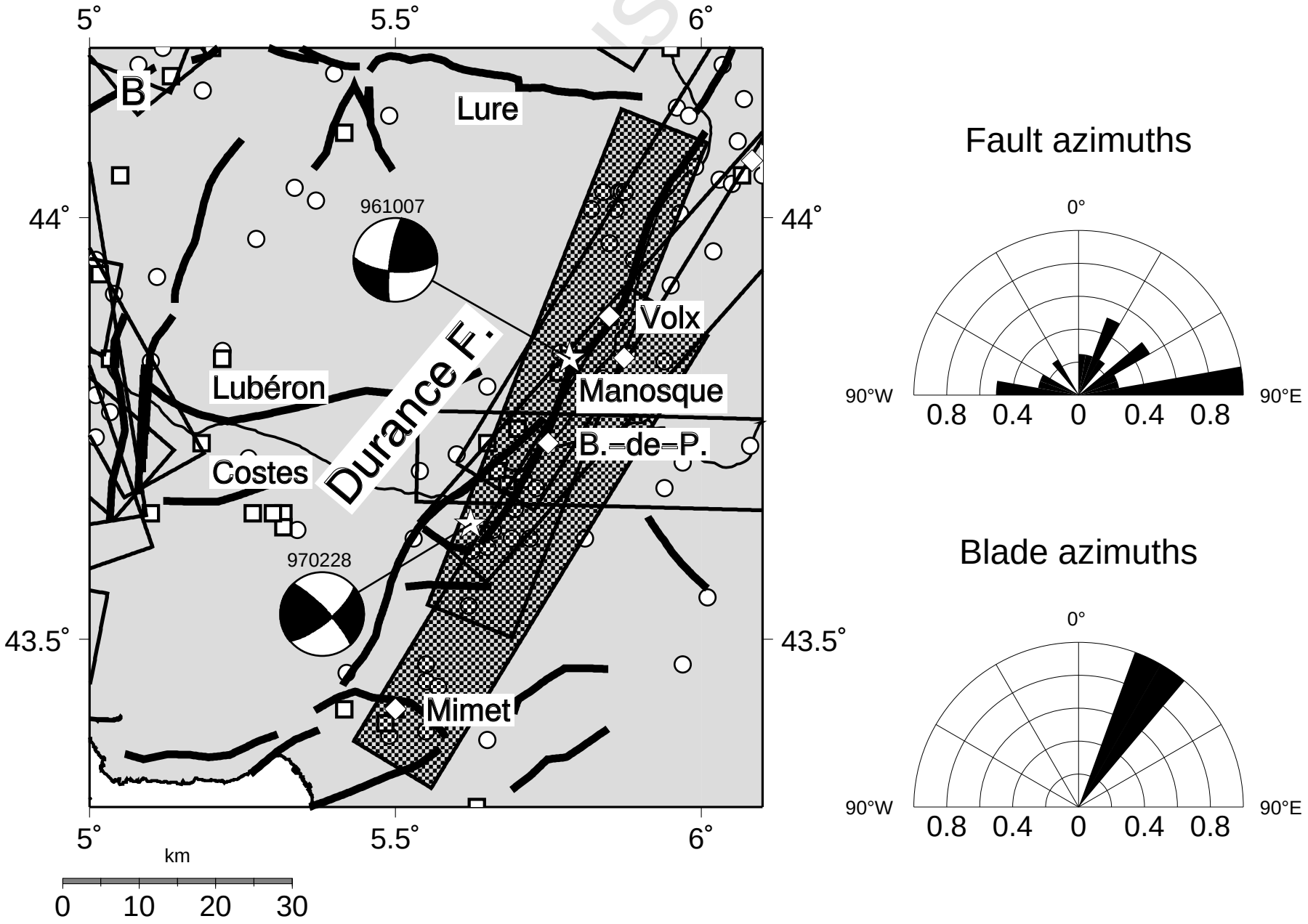
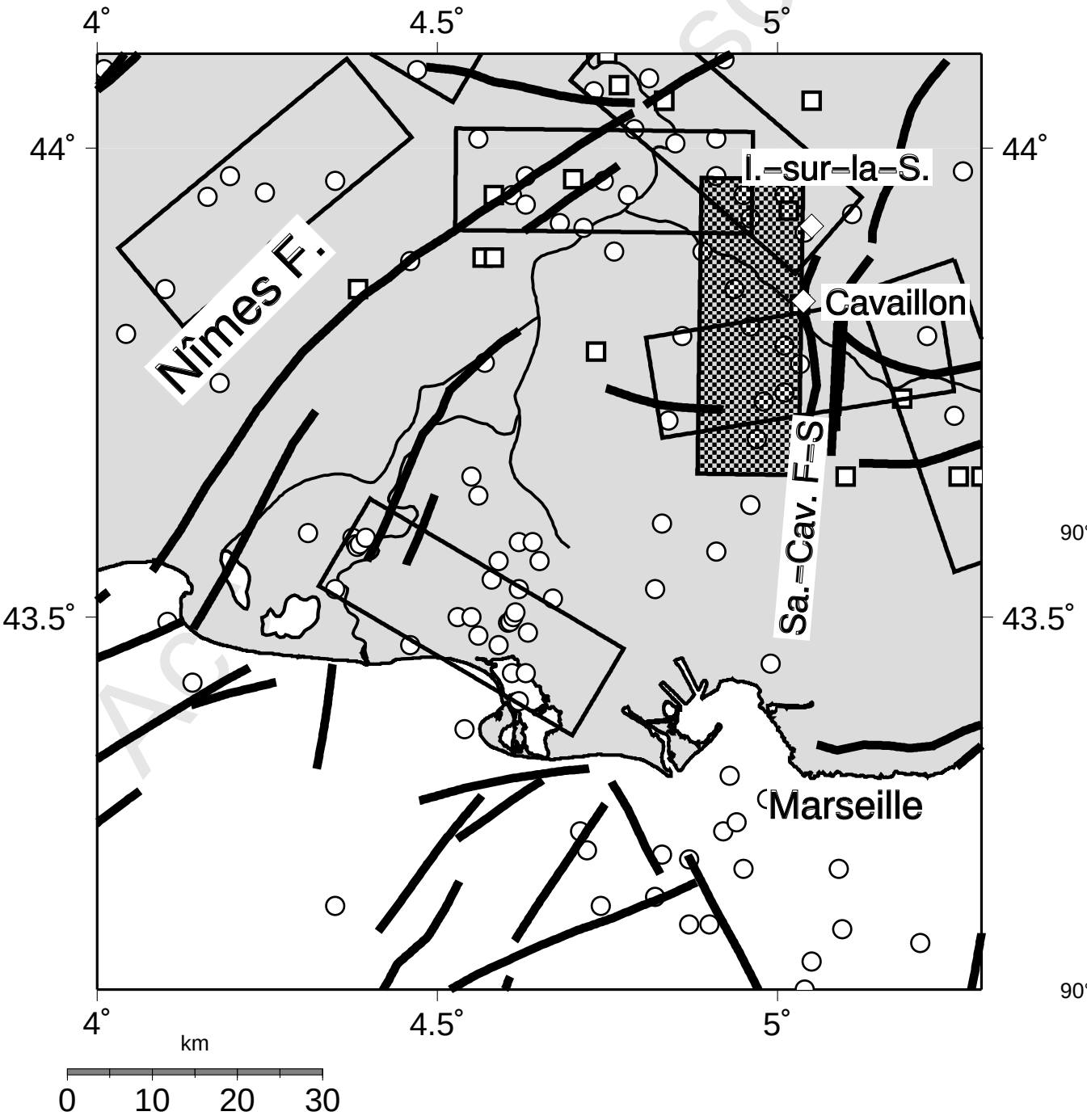
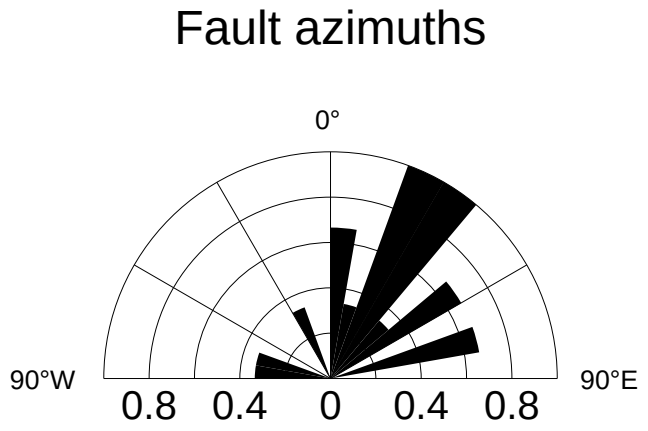


Figure 9. map Salon-Cavaillon





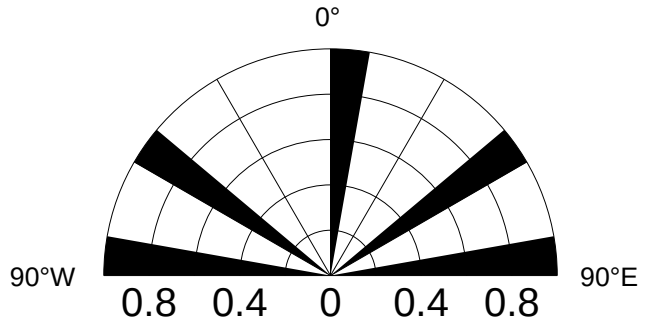


Figure 10. map Espinouse