Adv. Geosci., 14, 65–68, 2008
www.adv-geosci.net/14/65/2008/

Advances in Geosciences

The INGV tectonomagnetic network

F. Masci, P. Palangio, and M. Di Persio

Istituto Nazionale di Geofisica e Vulcanologia, Italy

Received: 11 June 2007 – Revised: 24 August 2007 – Accepted: 24 August 2007 – Published: 2 January 2008

Abstract. The Italian *Istituto Nazionale di Geofisica e Vulcanologia* (INGV) tectonomagnetic network was installed in Central Italy since the middle of 1989 to investigate possible magnetic anomalies related to earthquakes. The network is part of the INGV L'Aquila Geomagnetic Observatory and is located in an area extending approximately in latitude range [41.6°–42.8°] N and longitude range [13.0°–14.3°] E. Actually the network consists of four stations where the total magnetic field intensity data are collected using proton precession magnetometers. New stations will be added to the network starting from the end of 2007. Here we are reporting the whole data set of the network's stations for the period 2004–2006. No significant anomaly in the local geomagnetic field correlated to the seismic activity has been found. Some considerations about misleading structures present in the data sets are reported.

1 Introduction

Stress changes in the Earth's crust associated with the seismic and volcanic activity can be linked to local magnetic anomalies (Stacey, 1964; Hayakawa and Fujinawa, 1994, Johnston and Parrot, 1998). The observation of these anomalies is quite difficult because their amplitude depends principally on the intensity of the seismic events, on the involved physical mechanisms and on the distance between the earthquake hypocenter and the observation point. Moreover, coseismic field changes are larger than preseismic and postseismic changes because the observed coseismic effects are due to the release of the accumulated crustal stress during the entire earthquake duration, whereas the preseismic signals are due to a small fraction of the accumulated energy release (Mueller and Johnston, 1998). This is the reason for the great difficulty in the precursive signals detection. From the seismic point of view, Italy is an area with several active faults (see Fig. 1) and it was characterized in the past by a lot of wasteful earthquakes. Several studies have reported examples of correlation between anomalous electromagnetic signals and the tectonic activity in Central Italy (De Lauretis et al., 1995; Biagi et al., 2003). Moreover, anomalous acoustic signals and anomalous electric and magnetic signals related to the M=3.9 Gran Sasso earthquake occurred on 25 August 1992 are shown in Bella et al. (1998).

Correspondence to: F. Masci
(masci@ingv.it)

2 The Central Italy tectonomagnetic network

The INGV tectonomagnetic network was installed in Central Italy since the middle of 1989. At the present time, total magnetic field intensity data are collected in four stations using proton precession magnetometers. The network's stations are: L'Aquila (AQU), Monte di Mezzo (MDM), Civitella Alfedena (CVT) and Leonessa (LEO). In Fig. 1 the locations in Central Italy of the stations are reported. The sampling rate of each station is set to 15 min except for the AQU Observatory in which the sampling rates are 1 min and 1 s. At the beginning of 2006, in the frame of the MEM (Magnetic and Electric fields Monitoring) Project, it has been decided to upgrade the network (Masci et al., 2007). The MEM Project has been activated in the INGV Observatory of L'Aquila since 2004 (Palangio et al., 2007[1]). The leader partner of this project is the Italian Abruzzo Region. During 2007 new stations will be added to the network and the instrumentation of each station will be updated with an Overhauser magnetometer and a 3-axial magnetometer in order to widen the frequency band till 1 Hz and to get vectorial magnetic data.

[1]Palangio, P., Di Lorenzo, C., Di Persio, M., Masci, F., Mihajlovic, S., Santarelli, L., and Meloni, A.: Electromagnetic monitoring of the Earth's interior in the frame of MEM project, Ann. Geoph.-Italy, submitted, 2007.

Published by Copernicus Publications on behalf of the European Geosciences Union.

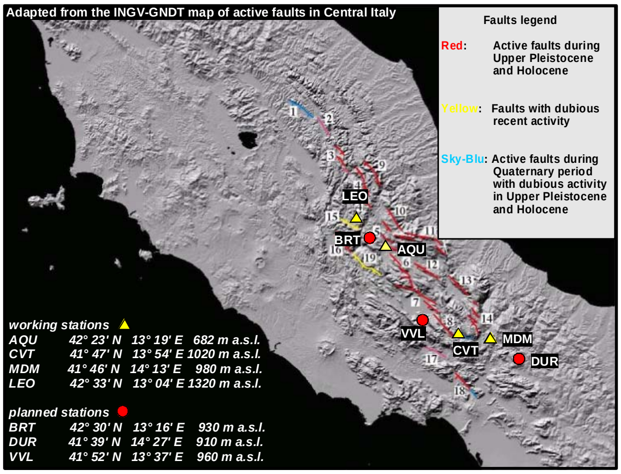

Fig. 1. Faults distribution in Central Italy. The locations of the INGV tectonomagnetic network stations are also reported.

Three potential sites as station locations were chosen at the end of 2006. Figure 1 shows the locations of these sites: Barete (BRT), Duronia (DUR) and Villavallelonga (VVL). Afterwards, some test campaigns have been carried out to check the electromagnetic background noise level of the new sites. The results of these tests have shown that only BRT and VVL sites are suitable for the installation of a geomagnetic station, whereas the VVL background noise is too high for this purpose and this site has been rejected (Masci et al., 2007). Actually we are searching for a new site to fill the gap between the AQU and the CVT stations. Concerning the data analysis, a different approach that takes into account the inductive effects on the total geomagnetic field intensity by means of the inter-station transfer functions time variations analysis (Chen et al, 2006) is planned as soon as the upgrade of the stations with vectorial magnetometers will bring to a conclusion.

3 The 2004–2006 data set and the deceptive events

The top panel of Fig. 2 reports the whole data set of the network for the period of years 2004–2006 as daily means of the total magnetic field. Each station data set is differentiated respect to the data set of the other stations in order to detect local field anomalies. The differentiation procedure removes the contributions from the other sources, external and internal to the Earth. The only remained one is due to the local variation in crustal magnetization and to the tectonic activity as well. A daily mean of the differentiated data is calculated to remove the diurnal variation. The LEO station data set is not reported in the figure because of the large number of gaps in the data due to technical and logistic problems. Bad weather conditions in winter, and the location of the LEO station in a rather inaccessible place, at relatively high altitude,

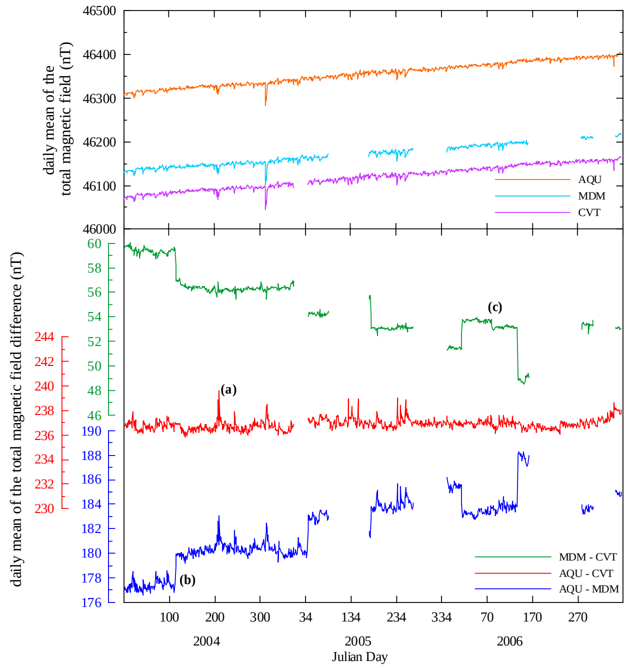

Fig. 2. Top panel: 2004–2006 data sets reported as daily means of the total magnetic field recorded in each station. Bottom panel: 2004–2006 daily means of the total magnetic field differences for the couple of stations AQU-CVT, AQU-MDM, MDM-CVT. The colour of each plot is the same of the corresponding vertical axis.

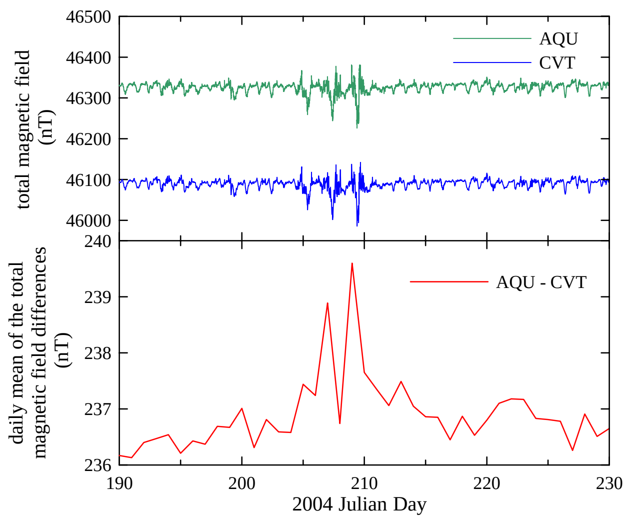

Fig. 3. Details of the event marked (a) in Fig. 2. In the upper panel are shown the total geomagnetic field intensities registered in the stations of AQU and CVT for the period of days JD=190–230, 2004. Both the signals show the presence of a magnetic storm beginning at JD=204 and ending at JD=211. In the lower panel is reported the daily mean of the differences of the two signals shown in the upper panel. An evident latitude dependence of the magnetic storm can be noted.

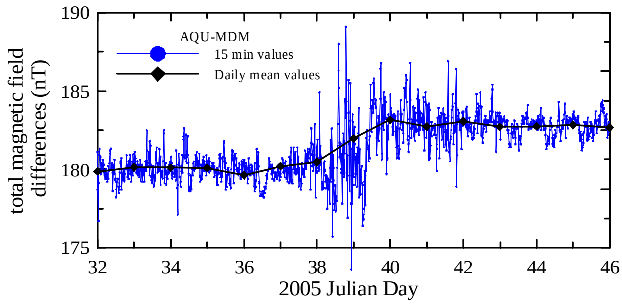

Fig. 4. The event marked (b) in Fig. 2 is reported in details. The event shows a jump of ∼2.5 nT in the differences AQU-MDM throughout 2 days.

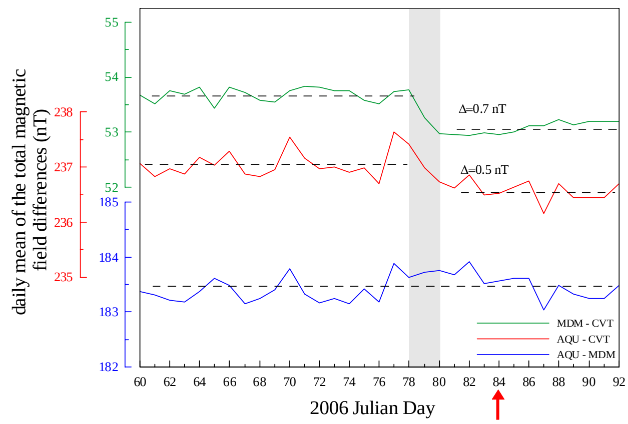

Fig. 5. The events marked (c) in Fig. 2 is reported in details. The red arrow shows a seismic event (M=3.1) occurred six days after the magnetic anomaly appearance.

also affect the continuity of the measurements. The bottom panel of Fig. 2 shows the differences among the stations of AQU, CVT and MDM as daily means. During the reported period no significant seismic activity has been recognized in Central Italy. The maximum magnitude of the local earthquakes estimated during this period is about M=3.5 (INGV seismic Bulletin, 2004–2006), so no significant anomaly in the local geomagnetic field is expected. In any case we want to stress some structures present in the differences that can mislead us during the data analysis. First of all, in the bottom panel of Fig. 2 can be pointed out some peaks with an amplitude about 2–3 nT in the AQU-MDM and in the AQU-CVT differences. These peaks do not appear in the differentiated dataset MDM-CVT. For example, we can analyze the peak marked (a) in Fig. 2. The lower panel of Fig. 3 shows in detail the peak (a) presented in the AQU-CVT differences, whereas the upper panel of Fig. 3 reports the signals of the total geomagnetic field for the stations AQU and CVT in the same period. Note that the total geomagnetic field differences are reported as daily mean, while total geomagnetic field signals, shown in the upper panel, are reported with the original acquisition time step. Both the total geomagnetic fields show a magnetic storm beginning at JD=204 and ending at JD=211. In the same period a peak appears in the AQU-MDM differences, while it doesn't in the differences MDM-CVT. This effect can be explained with an evident latitude dependence of the magnetic storm between AQU and the other two stations. In the differences MDM-CVT the latitude dependence of the magnetic storm is not so obvious because the latitudinal difference of the two stations is about 1′. We can find (a)-type peaks during 2004 on JD=24, 244 and 315, and during 2005 on JD=18, 128, 135, 150, 191, 237, 243 and 255. Figure 2 also shows obvious presence of another kind of deceptive events marked as (b). Figure 4 reports in detail the event beginning on JD=38, 2005. In the differences AQU-MDM the event consists in a jump, between two levels, of ∼2.5 nT during 2 days. This effect is due to the MDM total geomagnetic field intensity as it is presented in the differences AQU-MDM and MDM-CVT and it is not evident in the differences AQU-CVT. We can exclude instrumental problems as after the event occurred on JD=112, 2004 we changed the MDM instrumentation with a new calibrated magnetometer, but after about a year we have recorded a similar event on JD=38, 2005 in the MDM station (Masci et al., 2006). Figure 2 shows a probable similar event for JD=175 2005, happened unfortunately immediately after a gap in MDM dataset. In any case the lack of data doesn't permit to study in depth. A similar event has probably happened also during the data gap occurred in the period of days JD=272–345, 2006 since the mean values of the MDM-CVT differences before JD=272 and after JD=345 are different about 1.5 nT. It is also evident the presence of two jumps in the days JD=13, 2006 and JD=136, 2006 respectively of about 2 nT and 4 nT. Figure 2 shows probably a similar event happened unfortunately during the gap JD=160–277 in the MDM data set as can be seen by the different levels of the MDM-CVT and AQU-MDM differentiated data. Anyway, we want to point out that there are no relations between these events and the seismic activity in Central Italy. At this time, we have no reasonable explanation for these events. To better investigate these events, starting from the end of 2006 a second magnetometer is working in the MDM station simultaneously with the existing instrumentation. The instrument is an Overhauser magnetometer with an acquisition time step of 5 s. As last example of deceptive case, Fig. 5 reports the event marked (c) in Fig. 2. This event consists in a jump about 0.7 nT in the MDM-CVT difference beginning on JD=78 and ending on JD=80 of 2006. The event is also evident in the AQU-CVT differences but doesn't appear in the differences AQU-MDM station. Therefore, it seems that the magnetic anomaly can be linked with the signal recorded in the CVT station. Analysing the list of the earthquakes occurred in proximity of the station, we have found that six days after (JD=84) the CVT magnetic anomaly appearance, a seismic event has been occurred about 7 km away from the station in the South direction. At this point it seems evident that the CVT anomaly could be a seismic precursor, but we have to underline that the magnitude of the earthquake was about M=3.1 (INGV seismic Bulletin, 2006) so no significant anomaly in the local geomagnetic field is expected.

4 Conclusions

We have reported the whole data set of the INGV tectonomagnetic network for the period 2004–2006 both as the daily means of the total magnetic field and the differences between each network data set. No correlation between the registered magnetic anomalies and the local seismic activity has been found. Anyway no significant seismic activity has been registered in Central Italy in this period, so no significant anomalies in the local magnetic field is expected. Some types of misleading events are discussed in details to better underline the importance of an accurate and detailed analysis of each anomalous event encountered during the analysis of the tectonomagnetic data.

Acknowledgements. The authors are greatly indebted to the technical-administrative staff of the INGV L'Aquila Observatory for their support in the research activity. This work was supported by the MEM Project (Interreg IIIA Adriatic Cross Border Programme).

Edited by: P. Fabian
Reviewed by: two anonymous referees

References

Bella, F., Biagi, P. F., Caputo, M., Della Monica, G., Ermini, A., Plastino, W., and Sgrigna, V.: Anomalies in different parameters related to the M=3.9 Gran Sasso earthquake (1992), Phys. Chem. Earth, 23, 9, 959–963, 1998.

Biagi, P. F., Ermini, A., Piccolo, R., Loiacono, D., and Kingsley, S. P.: Electromagnetic signals related to micromovements of limestone blocks: A test in kart caves of Central Italy, in: Seismo Electromagnetics Lithosphere-Atmosphere-Ionosphere Cpoupling, edited by: Hayakawa, M. and Molchanov, O. A., Terrapub, Tokyo, 81–86, 2002.

Chen, K. J., Chiu, B., and Lin, C.: A search for a correlation between time change in transfer functions and seismic energy release in northern Taiwan, Earth Planets Space, 58, 981–991, 2006.

De Lauretis, M., De Luca, G., Scarpa, R., and Villante, U.: ULF geomagnetic field measurements during local seismic events, atti XIV° Convegno GNGTS, Roma, 23–25 Ottobre, 1995.

Hayakawa, M. and Fujinawa, Y. (Eds.): Electromagnetic Phenomena Related to Earthquake Prediction, Terra Sci. Pub. Comp., Tokyo, 677 pp., 1994.

INGV (Istituto Nazionale di Geofisica e Vulcanologia): Seismic Bullettin, Roma, 2004–2006.

Johnston, M. J. S. and Parrot, M., Electromagnetic effects of earthquakes and volcanoes, Phys. Earth Planet. In., Special Volume, 105, 109–295, 1998.

Masci, F., Palangio, P., and Meloni, A.: INGV tectonomagnetic network: 2004-2005 preliminary dataset analysis, Nat. Hazards Earth Syst. Sci., 6, 773–777, 2006,
http://www.nat-hazards-earth-syst-sci.net/6/773/2006/.

Masci, F., Palangio, P., Di Persio, M., and Di Lorenzo, C.: The development of the INGV tectonomagnetic network in the frame of the MEM Project, Nat. Hazards Earth Syst. Sci., 7, 473–478, 2007,
http://www.nat-hazards-earth-syst-sci.net/7/473/2007/.

Mueller, R. J. and Johnston, M. J. S.: Review of magnetic field monitoring near active faults and volcanic calderas in California: 1974–1995, Phys. Earth Planet. In., Special Volume, 105, 131–144, 1998.

Stacey, F. D.: The seismomagnetic effect, Pure. Appl. Geophys., 58, 5–22, 1964.