Network Assesses Earthquake Potential in Italy's Southern Alps

PAGES 262, 264

On 6 May 1976, a magnitude 6.4 earthquake struck the Friuli region of northeastern Italy near the towns of Gemona and Venzone. Although it was not as large as some previous earthquakes in Italy, its severe ground motion (up to 0.36 g) affected an area with numerous historical towns, resulting in 989 fatalities and 45,000 people left homeless. At least four other destructive earthquakes with epicentral intensity greater than or equal to IX on the Mercalli-Cancani-Sieberg scale have occurred in the Friuli region in the last 5 centuries (1511, 1700, 1794, and 1928) [*Slejko et al.*, 1999].

To better understand the seismic hazards of this vulnerable area, a network of continuously operating Global Positioning System (GPS) receivers—the Friuli Regional Deformation Network (FReDNet)—was installed to monitor the regional distribution of crustal deformation (Figure 1).

FreDNet's geodetic network is operated by the Centro Ricerche Sismologiche (CRS) of the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS). Funding for the project is provided by the OGS and the Italian Ministry for Scientific Research. The principal goals of the FReDNet program are to determine the distribution of deformation in the Italian section of the southern Alps, to estimate interseismic strain accumulation on its active faults, to monitor hazardous faults for emergency response management, and to establish an infrastructure for geodetic data management and processing.

FReDNet would also be part of a proposed larger program of geodetic monitoring that includes repeated episodic measurements of geodetic points with GPS. The network installation and data analysis began in the summer of 2002. Four continuous GPS stations are currently operating and three more will be installed by the end of 2003 (Figures 1 and 2). The GPS sites, many of which are located with existing OGS seismic monitoring stations, are distributed within and around the Friuli seismogenic area [*Bressan et al.*, 1998], which is centered northeast of the station MPRA (see Figure 1).

Site locations were chosen to capture most of the expected tectonic deformation across the seismic area, which may be on the order of a few millimeters per year [*Anderson and Jackson*, 1987], while taking into account local infrastructure and monument stability considerations. For example, station MDEA (Figure 1) is located on the only existing bedrock outcrop in the southern Friuli plain. We anticipate that estimates of geophysically useful velocities will be available within 2 to 3 years [e.g., *Blewitt and Lavallée*, 2002].

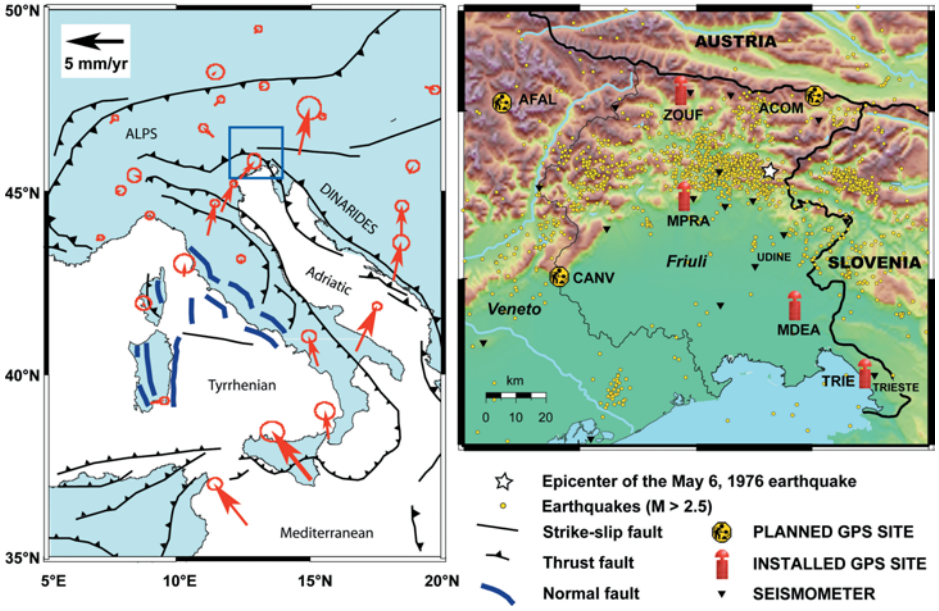

Fig. 1. The tectonic setting and 1999–2002 Global Positioning System (GPS) horizontal velocities (red arrows with 95% error ellipses) of the Adriatic region are shown relative to a European fixed-reference frame. The blue square (left) identifies the area monitored by FReDNet (right). The panel on the right shows the locations of the continuous GPS stations in the southern Alps. The project integrates the GPS network with the existing seismic network. Most sites are located on dolomite or limestone outcrops.

Monitoring Active Tectonics

The area monitored by FReDNet lies at the northeastern edge of the Adriatic region, a block of continental lithosphere underlying Sicily, parts of the Italian peninsula, and the Albanian and Croatian coastal regions (Figure 1). The Adriatic region is part of a zone of distributed deformation between the African and Eurasian plates. Seismic activity is concentrated in a belt that runs through the Italian peninsula and the Balkans, roughly corresponding to the Apennines, Alps, and Dynarides mountain chains. The continuous GPS-measured site motions vary across the Adriatic region, decreasing from south (~5 mm/yr) to north (~2 mm/yr) relative to Eurasia. Considerable uncertainty, however, surrounds the present-day kinematics of the Adriatic area, seen alternatively as a northern promontory of the African plate, or as an independent micro-plate within the Africa-Eurasia plate boundary zone [*Anderson and Jackson*, 1987; *Oldow et al.*, 2002].

The Friuli region (Figure 1) has a complex tectonic history that results from the superposition of several accretionary and shortening phases of the south Alps and Prealps. Relatively little is known about the regional deformation field and specific active faults. The seismic activity recorded since 1977 by the OGS is mainly concentrated in central Friuli between 7.5-km and 11-km depth. The focal mechanisms show thrusting on east-west-striking, low-angle faults, accompanied by some southwest-northeast and northwest-southeast strike-slip faulting in the western and eastern parts, respectively, consistent with a compressional stress field oriented primarily north-south to northwest-southeast [*Bressan et al.*, 1998].

Fig. 2. GPS site installation at Zouf Plan (ZOUF) is shown. The station is located on a Carboniferous dolomite outcrop. The typical network monument (shown on the right side) consists of a 1-m concrete pier attached to surface bedrock using epoxied metal rods. The chokering antenna is attached to the monument using an antenna adapter and is covered by a dome. The antenna cable is trenched to a nearby structure housing the seismic data loggers and GPS receiver. Cellular modems are used to telemeter the data once per day, using the SHARC/EGADS data acquisition software to control the data retrieval.

The 1976 main shock (local magnitude M_L = 6.4) was located in the eastern part of the Friuli region (Figure 1). The mechanism was nearly pure thrusting on a low-angle, north-

dipping fault. The aftershock activity (four earthquakes with M_L between 5.1 and 6.1), and background seismicity recorded thereafter by the OGS network, indicate an overall deepening of the earthquake foci to the north, which is in agreement with the main shock thrusting mechanism [*Slejko et al.*, 1999]. With the exception of the M_L 5.9 Krn mountains earthquake that occurred in nearby Slovenia on 12 April 1998, the current seismic activity in this region features small events ($M_L < 5$) followed by short aftershock sequences.

Data Archive and Distribution

All data related to FReDNet are available at http://www.crs.inogs.it/frednet/. The archive includes daily raw and RINEX data files, log sheets, station descriptions, and daily time series of station position. Daily RINEX files for the station ZOUF are also available through the German Agency for Cartography and Geodesy (BKG) GPS/GLONASS Data Center and the Italian Space Agency GEODAF data base.

Acknowledgments

G. Duri, F. Ponton, and P. Di Bartolomeo provided extensive field support and technical knowledge during this project.

References

Anderson, H., and J. Jackson, Active tectonics of the Adriatic region, *Geophys. J. R. Astron. Soc., 91*, 937–983, 1987.

Blewitt, G., and D. Lavallée, Effect of annual signals on geodetic velocities, *J. Geophys. Res., 107*, 2145, doi: 10.1029/2001JB000570, 2002.

Bressan, G., A. Snidarcig, and C. Venturini, Present state of tectonic stress of the Friuli area (eastern Southern Alps), *Tectonophys., 292*, 211–227, 1998.

Oldow, J. S. et al., Active fragmentation of Adria, the north African promontory, central Mediterranean orogen, *Geology, 30*, 779–782, 2002.

Slejko, D. et al., Stress field in Friuli (NE Italy) from fault plane solutions of activity following the 1976 main shock, *Bull. Seismol. Soc. Am., 89*, 1037–1052, 1999.

—MAURIZIO BATTAGLIA, Seismological Laboratory, University of California, Berkeley, and Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Udine, Italy; DAVID ZULIANI, DAVIDE PASCUTTI, ALBERTO MICHELINI, and IGINIO MARSON, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Udine, Italy; and MARK H. MURRAY and ROLAND BÜRGMANN, Seismological Laboratory, University of California, Berkeley

SECTION NEWS

SPACE PHYSICS & AERONOMY

PAGE 263

Hill Receives 2003 F. L. Scarf Award

Matthew Hill was awarded the F. L. Scarf Award for his thesis titled *Transport phenomena of anomalous cosmic rays during the recovery phase of solar cycle 22*. He will be formally presented the award during the AGU 2003 Fall Meeting, which will be held 8–12 December in San Francisco, California. The award is given annually to a recent Ph.D. recipient for outstanding dissertation research that contributes directly to solar-planetary science.

Matthew received his B.S. in physics, with high honors, from Rutgers University, New Brunswick, New Jersey, in 1996. He was then granted a Distinguished Research Fellowship for graduate studies in the Department of Physics at the University of Maryland, College Park. Supervised by Douglas C. Hamilton, Matthew earned his M.S. in 1998 and his Ph.D. in physics in 2001. He is currently a research associate at the University of Maryland, where he continues his heliospheric research on the transport of anomalous cosmic rays using particle measurements from the Voyager deep-space probes.

Last year, he also joined investigations involving the imaging of magnetospheric neutral atoms with instruments aboard the IMAGE spacecraft.