The GEOFON Program

Winfried Hanka (*) **and Rainer Kind** (*)

Following the long tradition in broadband seismology in Germany, the GeoForschungsZentrum (GFZ) at Potsdam, an institution for interdisciplinary research in geosciences, founded in 1992 by the Federal Ministry of Research and Technology, has started a program for the establishment of a network of globally distributed broadband seismic stations. The program, called GEOFON (GEOFOrschungsNetz), is dedicated to Ernst von Rebeur-Paschwitz who recorded the first teleseismic seismogram 1889 in Potsdam and proposed a global seismograph network and an earthquake reporting system. Our program will, after its completion, consist of three parts: a permanent network of about 30 stations, a portable broadband network and a comprehensive data archive. It is planned for two three-year periods (1993-1995 and 1996-1998). The funding for the first period has already been provided almost completely. An Advisory Board with members from German Universities and the GFZ guides the operation of GEOFON.

The main task of the program is to serve the seismological community with high quality broadband data for all kinds of scientific tasks. The research projects at the GFZ itself, to be carried out with GEOFON and other broadband data, are presently dealing mainly with lithospheric and upper and lower mantle 3-D structure.

The permanent seismic network

The permanent GEOFON network has two major goals: one is to fill at least some gaps in the global VBB network in cooperation and coordination with other member networks from the Federation of Digital Seismograph Stations (FDSN). The other important task is the densification of the FDSN network for high resolution regional studies of seismicity and earth structure by upgrading existing seismological observatories with modern broadband equipment in certain areas. In the first phase, this part of the program focuses on stations in Europe, especially Eastern Europe, but also some parts of Western Europe.

The present GEOFON siting plan is shown in figs. 1 and 2. For the installation and operation of some global stations, equipped with STS-1 seismometers, a comprehensive cooperation between the GFZ and IRIS/USGS was established in 1993. Under this agreement, the deployment of five joint stations in different parts of the world is planned: Port Moresby (New Guinea) (PMG, installed in September 1993), Antofagasta (Chile), Nairobi (Kenya), Ny Alesund (Spitsbergen) and Sondre Stromford (Greenland). At two of these sites, a third partner has joined the bilateral cooperation: POSEIDON at PMG and the Alfred-Wegener-Institute for Polar Research in Bremerhaven (AWI) in Spitsbergen.

Two more GEOFON stations equipped with STS-2 seismometers were installed in late 1993: MORC in Northern Moravia (Czech Republic) in cooperation with the Masaryk University Brno and DSB near Dublin (Ireland) with the Dublin Institute for Advanced Studies. More stations are to be installed in the first half of 1994 in Walferdange (WLF, Luxembourg), Muntele Rosu (MLR,

(*) GeoForschungsZentrum, Potsdam, Germany.

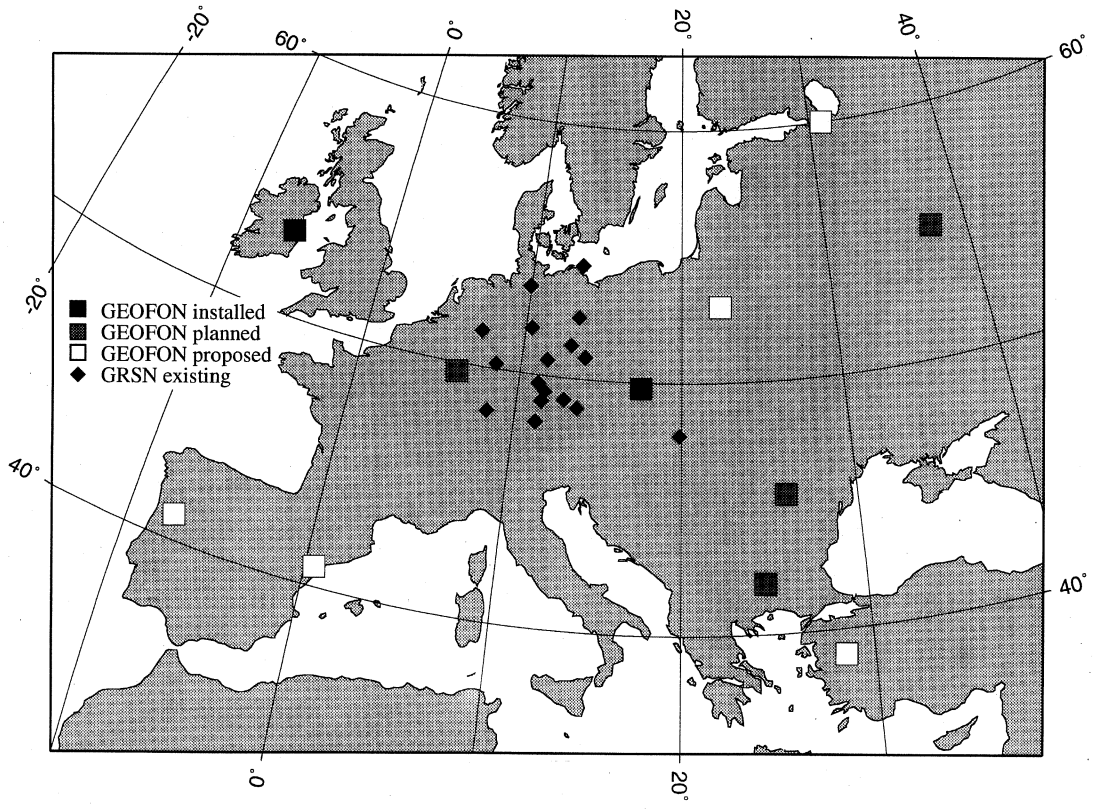

Fig. 1. GEOFON and GRSN station distribution in Europe.

Romania) and Michnevo (near Moscow, Russia). Other planned stations are presently Nord (Northern Greenland) and Sanae (Antarctica) in cooperation with the AWI, Plovdiv (Bulgaria) in cooperation with MEDNET, Tashkent (Uzbekistan) and Yogyakarta (Indonesia). Proposals for additional sites on Iceland, the Iberian Peninsula, St. Petersburg (Russia), NE Poland or Lithuania, Turkey, Kirgizstan and Chile are being discussed presently by the Advisory Board.

The station hardware

According to the different tasks, two different station types are used for permanent installations: the GRSN- and FDSN-type systems. Since they represent the defacto standard in VBB seismology, in both cases Quanterra systems were chosen as the basic data logger. The FDSN-type systems, because all of those planned for the first phase of the program are joint stations with IRIS-ASL, are orientated to IRIS standards. They are equipped with STS-1 sensors and IRIS-2 data loggers, separated in a 9-channel Quanterra data aquisition (DA) unit and a station data processor (DP) with 400 MB disk space and two 150 MB QIC cartridge tape drives with an intra-site communication link in between. In some sites the compact version of the IRIS-2 data logger is or will be used.

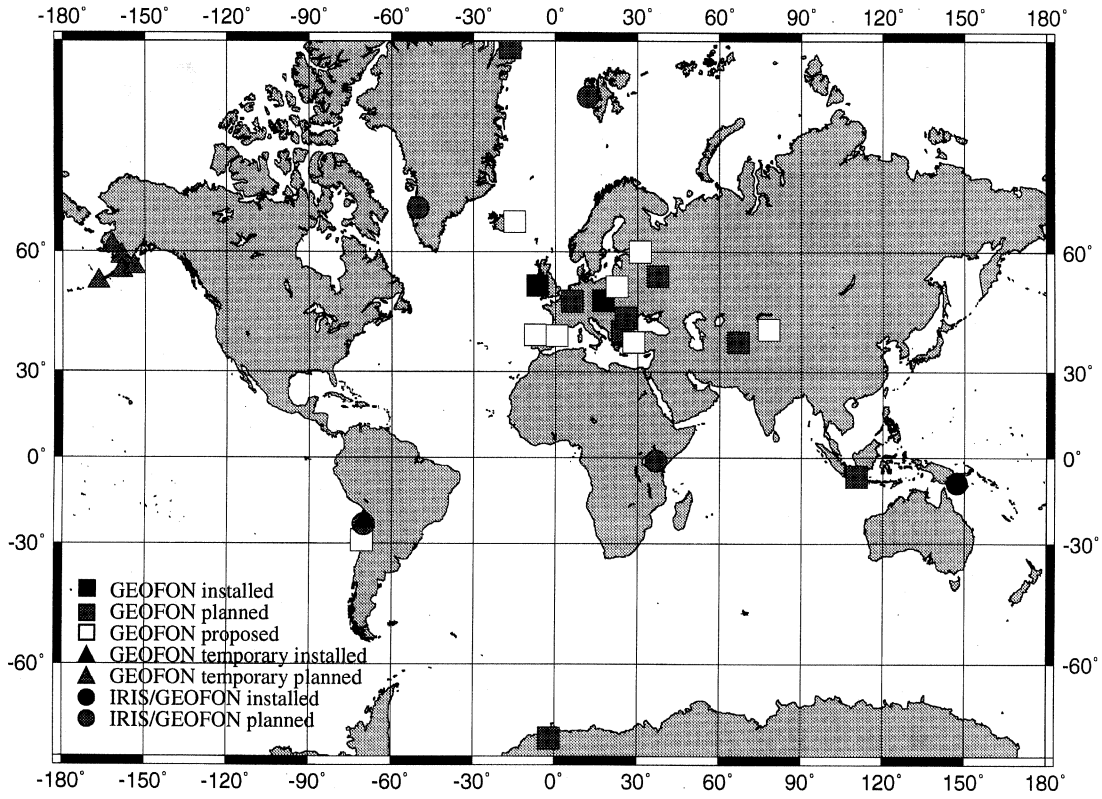

Fig. 2. Global GEOFON station distribution.

The GRSN-type systems for more regional purposes consist of a STS-2 VBB seismometer and a compact Q380/LT-G data logger equipped with three 24 bit 80 sps digitizers, a 68030 CPU board with 4 MB memory, 200 MB internal disk, a 150 MB QIC magnetic streamer, 4 serial ports and an external SCSI connector. In some cases, six-channel Q680 systems will be used to operate additional strong motion sensors. Three different data streams (20, 1 and 0.1 sps) are stored continuously and one on a triggered basis (80 sps). The STS-2 sensors are additionally shielded against long period temperature and pressure variations as well as corrosion using a specially designed aluminium casing with a 5 cm thick base plate. With this shielding, the long period resolution of the STS-2 is improved substantially and comes for most purposes close to the STS-1 sensors. Both stations types are completed with high speed dial-up modems, graphical displays and laser printers and uninterruptable 24 VDC power supplies. Timing is performed normally by a GPS time receiver.

Temporary deployment of broadband stations

The GFZ is establishing a pool of seismic stations for active and passive experiments, comparable to the IRIS-PASSCAL program. At present, this pool consists of about 130 PDAS 100 and

REFTEK 72A-07 data loggers and a set of sensors including 12 GURALP CMG3-T broadband instruments. The GEOFON program is responsible for the broadband part of this pool.

The first project of this kind has already started: a passive seismic tomography experiment carried out between January and May 1994 in the Atacama basin, east of Antofagasta (Northern Chile) by the GFZ and Free University of Berlin. Here a total of about 25 mobile stations including four BB stations equipped with STS-2 sensors and PDAS 100 data loggers are distributed over an area of 100 by 50 km. Four mobile stations equipped with Guralp CMG3-T sensors several hundred km north and south of the investigated area and a semi-permanent GEOFON station installed near Antofagasta as reference stations, complete this experiment. The installation of the GEOFON station has also another goal: to investigate noise and other conditions for the planned GEOFON-IRIS station at a new site near Antofagasta.

A second longer term project takes place in the Eastern Aleutian Island and Western Alaskan Peninsula, where five stations will be installed for about two years in cooperation with the University of Alaska in Fairbanks to study the subducting Pacific plate and the seismicity in and around the Shumigan Islands. Three complete GEOFON stations have already been shipped to Alaska for test installations and the whole set should be installed in the final locations by early summer of 1994.

The next temporary operations including broadband sensors will take place in Tibet in the second half of 1994 (a cooperative project with PASSCAL) to investigate the lithospheric structure, a deployment in Denmark and Southern Sweden in early 1995 to study the Tornquist-Tesseyre Line and a larger experiment in the Carpathians also in 1995.

The GEOFON Data Center

As part of the bilateral cooperation IRIS-GEOFON, the IRIS DMC helped to install data communication and archival software at the Potsdam GEOFON Data Center. The IRIS GOPHER system is now used to automatically access the GEOFON stations after major events to retrieve selected event data. The DIRTS data base system was installed to manage the archival of the mass station data received at Potsdam on magnetic cartridges. The data collection and processing of the data of the GEOFON and other stations is handled mainly on a set of two SUN 10/41 server systems with high disk capacity (more then 20 GB) and all necessary peripherial devices. As the main mass storage unit, a 18 TB METRUM RSS600/4 system with UNITREE archival software is available at the GFZ Computing Center through a CONVEX file server system.

The GEOFON online data pool

Triggered by the NEIS automatic alert messages or other more regional sources like EMSC or the GERESS alert system, automatic data retrieval is performed for all GEOFON stations accessible by phone lines (fig. 3). If possible, local INTERNET nodes in host institutes are used as sub-nodes in the GEOFON GOPHER system. In addition, a similar system based on X.25 communications is being developed, which will provide data from other German stations like the GRSN stations and the GRF and GERESS arrays. Since the GEOFON GOPHER system is one node in the global GOPHER system, direct access to data retrieved by the other GOPHER nodes like those at the IRIS DMC at Seattle or ORFEUS in Utrecht is available over INTERNET. Therefore, several hours after an event has occurred, high quality broadband data from all available sources are collected in the online data pool in Potsdam and available to the seismological community. The data can be accessed through the well known gopher-view user interface using the GOPHER or DRM data request manager accounts (passwords geofon) via INTERNET on st8.gfz-potsdam.de, via X.25 (262-45050231902) or via modem (+49-331-288-1293 to 1296).

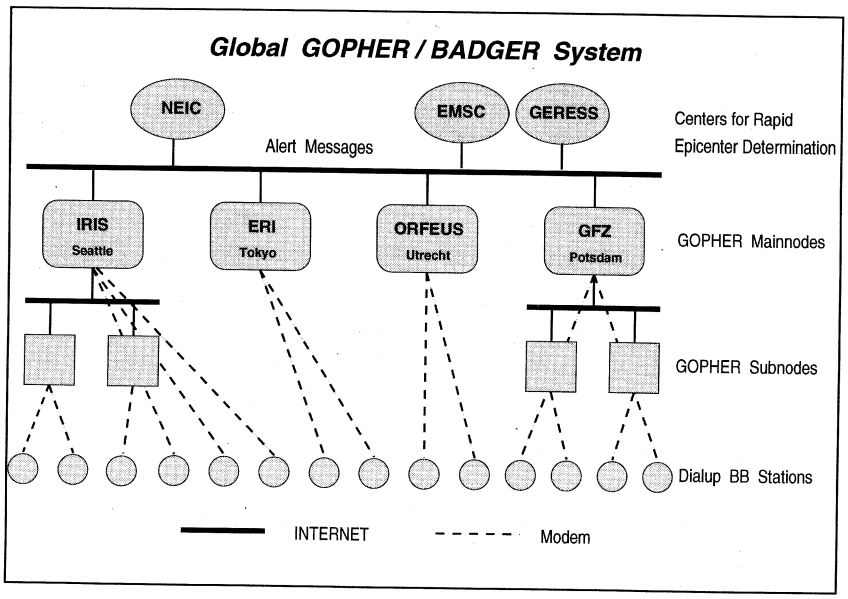

Fig. 3. Principal scheme of the distributed global GOPHER/BADGER system with different main nodes and regional sub nodes.

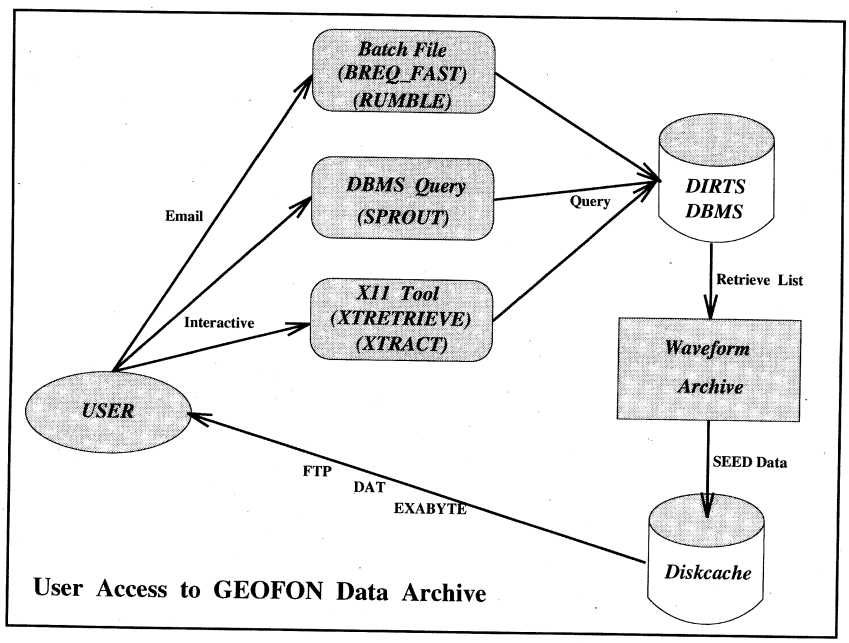

Fig. 4. User data retrieval from the GEOFON data archive in Potsdam.

The GEOFON data archive

Assembled data sets to be stored in the GEOFON data archive are received through a number of different sources. Beside the actual SEED data sets of all original GEOFON stations and associated stations (assembled directly in Potsdam), data sets from the joint IRIS-GEOFON stations (compiled at the IRIS/ASL DCC in Albuquerque), from the German broadband stations (assembled at the German Central Seismological Observatory in Erlangen) and also data sets of selected stations from other networks (*e.g.* IRIS, GEOSCOPE or MEDNET) will be stored in the GEOFON data archive using the DIRTS data base system. These data are freely accessible for the seismological community through the DRM account (see above) using the known IRIS developed user interfaces: by e-mail (BREQ_FAST and RUMBLE), SQL data base interface (SPROUT) and X-tools (XRETREIVE and XTRACT) (see also fig. 4).

The content of the data archive is still quite poor at the moment, since the first IRIS-GEOFON station PMG started operation in September 1993 and the GEOFON stations MORC and DSB in November and December 1993, respectively. But this situation will improve soon because more GEOFON and IRIS-GEOFON stations will shortly become operational and data of the GRF array (starting from 1976) and of the GRSN network (beginning in 1991), which were already copied from the original data media into the METRUM system, will be translated into full SEED volumes in a major effort during the next months and integrated into the GEOFON data archive and the DIRTS data base. The GEOFON data archive will then provide a new source of high quality broadband data to the seismological community. GEOFON data will also be available through the IRIS DMC (first FDSN data archive) and the ORFEUS Data Center.