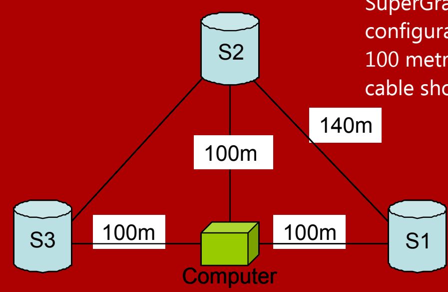
SUPER GRADIOMETER

Precise Earth Monitoring Solutions



SuperGrad sensor configuration 100 metre sensor cable shown.

The SuperGradiometer utilises GEM Potassium sensor technology and provides enhanced sensitivity to small disturbances in the gradient field in the picoTESLA range for specialized stationary applications.

Celebrating 35 Years

Leading the World of Magnetics

GEM Systems is the number one global leader in the manufacture and sale of high precision magnetometers.

GEM is the only commercial manufacturer of Overhauser magnetometers, that are accepted and used at Magnetic Observatories over the world.

Our Potassium Magnetometers are the most precise magnetometers in the world.

Our Proton sensors are considered the most practical and robust magnetometers for general field use.

Proven reliability based on 35 years of R&D

We deliver fully integrated systems with GPS and additional survey capability with VLF-EM for convenience and high productivity

Today we are creating the absolute best in airborne sensors with smaller and lighter sensors for practical UAV applications. We are also making very large sensors with the best sensitivity (30-50fT) for use in natural hazard research and global ionospheric studies.

Our Leadership and Success in the World of Magnetics is **Your key to success** in applications from Archeology, Volcanology and UXO detection to Exploration and Magnetic Observation **Globally.**

Earthquake Research - The search for Precursors

Magnetics have played a significant role in Earthquake studies for several decades. Based on the theory of piezomagnetism and / or piezokinetics, it offers a possibility of detection of precursors to earthquakes due to gradual pressure build-up. Three typical limiting factors include sensitivity, long-term stability and a need to eliminate environmental noise (diurnals, man made noise).

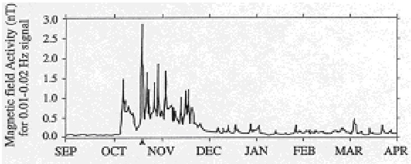
Early monitoring systems with sensitivities in the nT range and long base differential measurement produced in a few cases, startling precursors that could, however, be neither confirmed nor repeated. Some of the more recent work has employed induction coils with an improved sensitivity (25pT) but limited long term features (bandwidth down to 0.01Hz) and the results have been somewhat better. When detected, corresponding anomalies varied from few nT to few tens of pT (close to instrument's background noise).

Piezomagnetic anomalies vary substantially with the earthquake intensity, composition of rocks that come under pressure, geometry of pressure etc. Assuming that they are of dipolar character, their fields vary with the cube of distance (i.e. their detectability will be limited to a proximity to epicenters - or better, to hypocenters).

Subtle changes in Magnetic Field Observation required for Earthquake Research

More systematic results can only be obtained if the measurements can be done with substantially increased sensitivity; long-term stability; and by taking into consideration the very local character of dipolar magnetic field, large time variations of magnetic field (diurnals), noise and man-made noise. Magnetometers, need to work in differential mode to reach the best sensitivity - free of diurnals and man-made noise. Reference instruments that measure only temporal variations of the magnetic field are typically placed away from active zones, (long base), resulting often in imperfect elimination of diurnals and man-made noise.

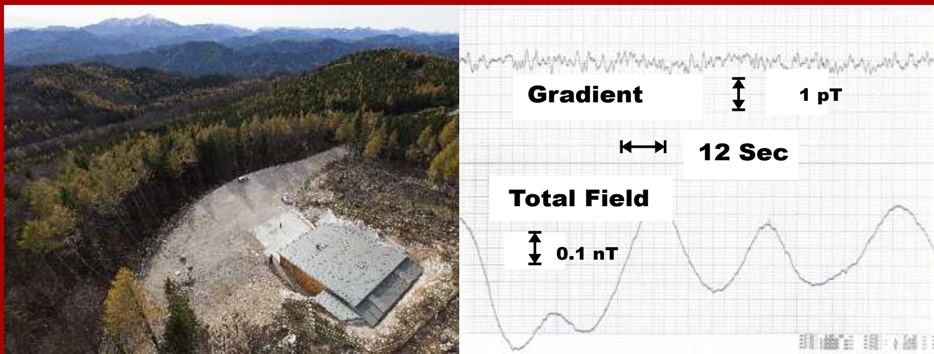
Earthquake research studies have shown large amplitude magnetic responses weeks and hours before events. Smaller events appear to exhibit less coherent patterns; likely due to the lack of sensitivity of traditional magnetic instruments.



Magnetic data before & after the Loma Prieta earthquake in California, 1989.

Our World is **Magnetics.**

GEM Systems, Inc.
135 Spy Court Markham, ON Canada L3R 5H6
Phone: 905 752 2202 • Fax: 905 752 2205
Email: info@gemsystems.ca • Web: www.gemsystems.ca



SuperGradiometer installed at the Conrad Earth Observatory on Austria.
(Sample data Total Field and Gradient with <1pTesla noise level)

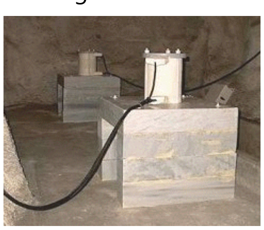
Global Applications

For earthquake research, the GSMP-20S3 can achieve gradient sensitivities better than 1fT/m (10^{-15} T/m) with a sensor spacing of 50m - a major advantage over traditional long-baseline measurements (i.e. total field with reference station for removal of diurnals) which only have sensitivities on the order of 1nT. The GSMP-20S3 also minimizes cultural noise (i.e. from nearby infrastructure), and minimization of 1 / f noise that typically degrades results from other types of measurements (ex. Electromagnetic). Note that f is the frequency of the piezomagnetic signal from the event.

From reports on the M7.1 earthquake (maximum magnetic anomaly B = 2.8nT at 7km distance to epicenter and 17km depth of hypocenter), one can calculate the magnetic moment. Using Bmax = 2.8nT and r = 18.38km, gives:

Moment = 1.74 x 1011 Am2

This type of analysis can be used to assess expected magnetic moments for various magnitudes and the distances to hypocen-ters at which they will produce anomalies equaling noise levels of magnetometers and induction coils.



SuperGradiometer installed near Eilat, geophysical laboratory Israel. Sensors and mounting platforms are shown.

Magnitude	Magnetic Moment Am^2	Detectable Distance (km)			
		Magnetometer 1nT	Magnetometer 0.1nT	SuperGrad 1fT/m	SuperGrad 0.1 fT/m
8	2.2×10^{12}	60	130	160	285
7	7×10^{10}	18	39	67.5	120
6	2.2×10^{9}	6	13	28.5	50.7
5	7×10^{7}	1.8	3.9	12	21.3
4	2.2×10^{6}	0.6	1.3	5.1	9
3	7×10^{4}			2.1	3.8

Comparison of different types of sensors, nominal moments and the maximum dis-tances (km) they can be detected.

This analysis re-inforces the ability of the SuperGradiometer (and Short Base Mea-surements) to detect extremely subtle phenomena.

Installation Considerations

GEM is currently recording data at a site in the middle East and Austria and is seeking to expand its installed base in tectonicaly active regions for earthquake prediction research. These measurements are complementary to other methods, such as seismics, GPS, radon, etc. that are now in use, and will provide essential information for data integration and analysis.

For optimal results, the system should be sited with sensors in a magnetically quiet region close to the fault system under investigation. The sensors should be sited in an enclosed structure and imobilised on stable base platforms to ensure repeatability of data throughout the monitoring period.

Specifications

Performance / Sensor
SuperGRAD and SuperGRAD Mini

SuperGrad Sensitivity: 0.03 pT @ 1Hz
Gradient sensitivity: 1 fT/m
with 50m sensor spacing
SuperGrad Mini Sensitivity: 0.05 pT @ 1Hz
Gradient sensitivity: 10 fT/m
with 50m sensor spacing

Resolution: 0.001 pT for up to 20 readings /sec.
Absolute Accuracy: 0.1 nT
Time Base Stability: 0.01 ppm over -40°C to +55°C
Long Term Stability: better than 10 pT / year
Dynamic Range: 20,000 to 100,000 nT
Operating Temperature: -40°C to +55°C
Power Consumption: 22-60 V
80 W average, 250 W maximum
Tuning: wideband system auto tuning
Sensor Orientation: 45 +/- 35 degrees off
the magnetic field direction

Sampling rate
1 to 20 samples / second

Output
Digital: serial RS232C
Analog: 4 programable channels
Visual: alphanumeric LCD
adjustable scales

Dimensions & Weights
SuperGrad Console: 48x9x41cm (19 x 3.5 x 16 in)
4.5 kg (10 lb)
Standard Sensor: 20.3 x 10.2 cm (8 x 4 dia in)
3.0 kg / 6.6 lb
Larger Sensor: 26.3 x 23dia cm (12 x 8.25dia in)
6.0 kg (13.2lb)
Sensor Electronics: 10 x 5 x 10 cm (4x2x4in)
Super Grad Cable Lengths: User-specified,
(100 - 300m)
Super Grad Mini Cable Length: 50m

Standard Components
GSMP-20S3 console, Power Supply Unit
3 Large Potassium sensors
with 3 sets of 50 or 100m cabling, GSMP-20S3 software, RS-232 cable and instruction manual.
Optional GPS for precise time values.
GEM also provides a Radon option
for SuperGrad.

The GEM Super Gradiometer GSMP 20S3 & 20S3M systems comes complete with an industry leading three year warranty

GEM Systems, Inc.
135 Spy Court Markham, ON Canada L3R 5H6
Phone: 905 752 2202 • Fax: 905 752 2205
Email: info@gemsystems.ca • Web: www.gemsystems.ca

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