2010 Ground Magnetometer Survey

On

Everton Recources Inc.'s

Shoal Lake Property – North Machin Option

Kenora Mining Division

Shoal Lake, Echo Bay, Showshoe Bay, and Glass Townships

NTS 52 E / 10 and 52 E / 11

March 17, 2010

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1.0 Summary

Clark Exploration Consulting was contracted in February-March, 2010 to conduct a 25m line-spaced ground magnetometer survey over a portion of Shoal Lake. A total of 52.8 line-km of cesium ground magnetometer were performed from February 28, 2010 to March 6, 2010. The focus of the exploration was on an area of the Shoal Lake Deformation Zone (SLDZ) where a large flexure occurs. Observable in airborne magnetics, this flexure was mapped in 1990 as an east-west trending dextral shear zone containing 4 gold occurrences within 1500 meters of strike length. The ground magnetometer survey was designed to test the detailed geophysical response in the area of the flexure to try and pickup features that may not have been realized in the airborne survey.

The survey was done on the ice using a snowmobile and non-ferrous dogsled carrying a geophysical technician wearing a Geometrics G-859 'back-pack' cesium-vapour magnetometer. A Geometrics G-856AX proton precession magnetometer was used as a base station for measuring and correction for diurnal variation. Post-processing and gridding was then carried out on the data.

While the survey was completed successfully, features that would be interpreted as structures representing second-order splays and zones of dilation were not recognized. Ground magnetics should be obtained for deviated lines in the southern portion of the survey, along with the eastern portion of the peninsula and stitched to the existing grid to help visualize the relationship to the gold showings.

2.0 Introduction

Clark Exploration Consulting was contracted in February-March, 2010 to conduct a 25m line-spaced ground magnetometer survey over a portion of Shoal Lake. A total of 52.8 line-km of cesium ground magnetometer were performed from February 28, 2010 to March 6, 2010. The following report describes the work carried out during the 2010 on-ice ground magnetometer survey.

3.0 Property Description

The Shoal Lake Property (hereafter referred to simply as "the Property") consists of 149 Mining Dispositions (patents / leases) totaling 2612 hectares (Table 1) and 44 Mining Claims totaling 6157 hectares located in Shoal Lake, Echo Bay, Showshoe Bay, and Glass Townships in the Kenora Mining Division (Table 2, Figures 1 and 2). The Property is a large land package consisting of option agreements between many different parties. The land package shown below (in both tables and figures) is the current extent of all contiguous options in the area.

The claims (K3019219 and K3019221) on which the ground magnetometer survey were performed are currently under option from Machin Mines (via John Scott Roberts). Figure 3 is a detailed map showing the location and extent of the claims.

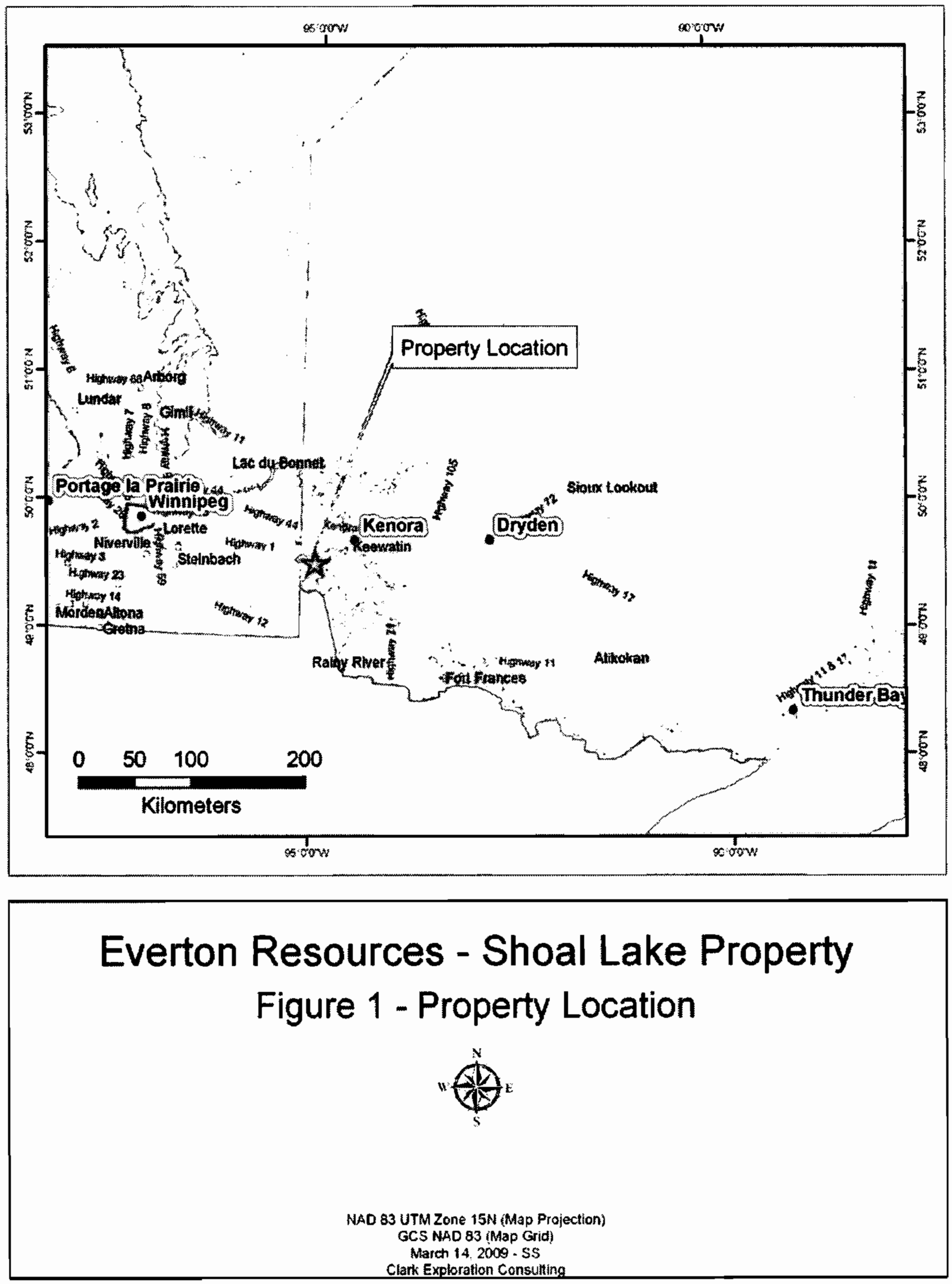

Figure 1: Property location.

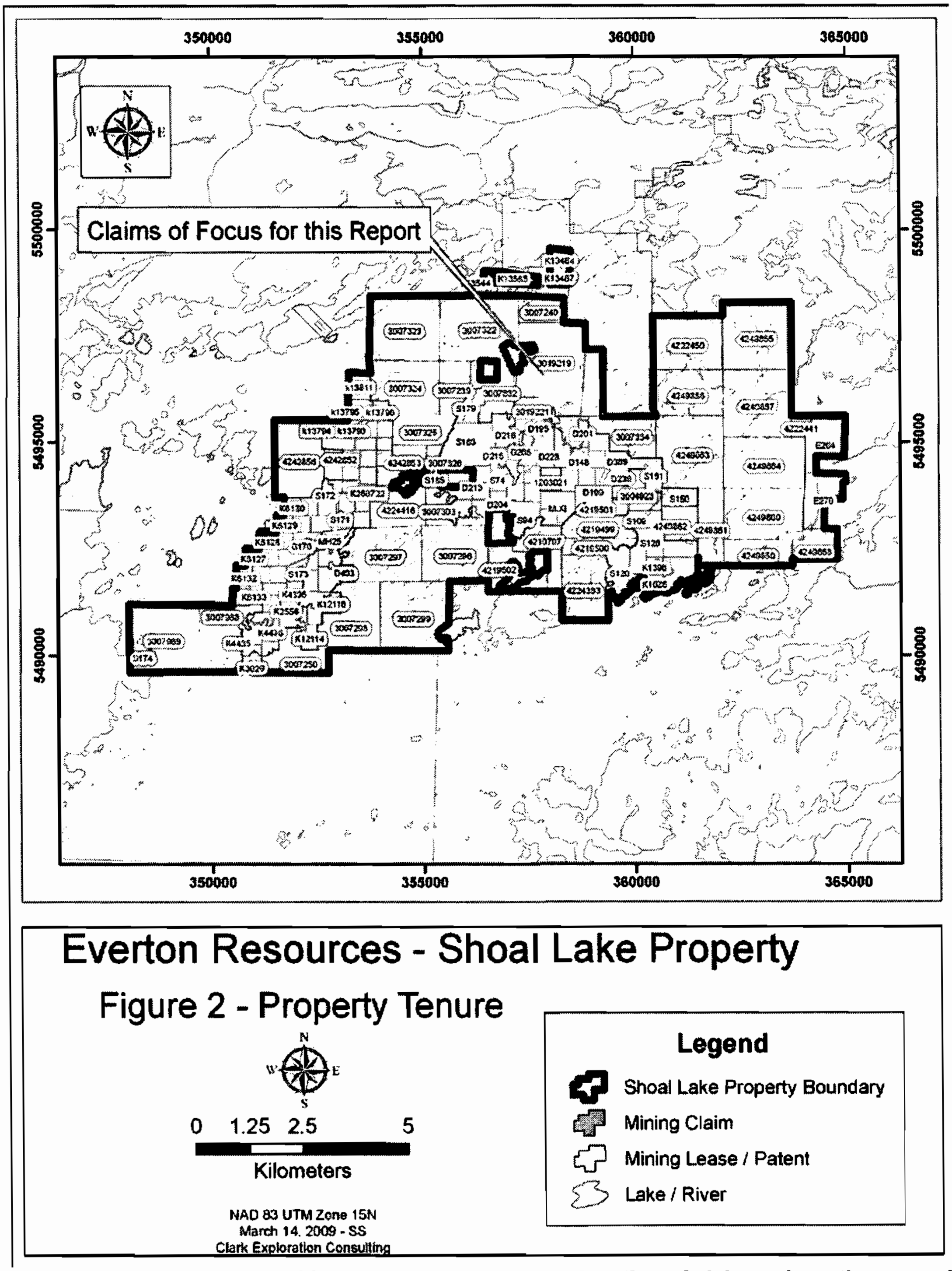

Figure 2: Property tenure with text box arrow showing location of claims where the ground magnetometer was performed and focus of this report.

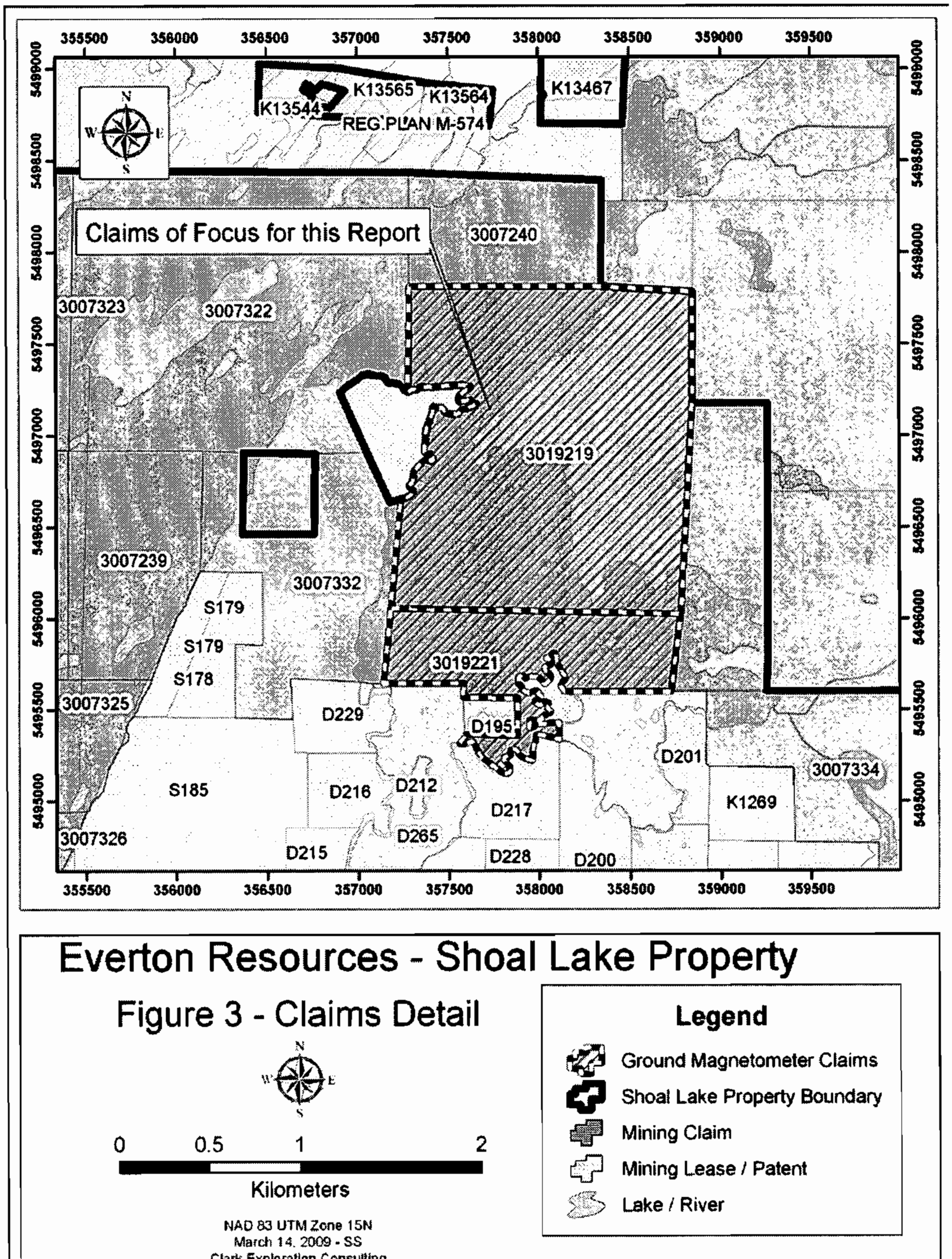

Figure 3: Claims on which ground magnetometer survey was performed.

Table 1: MNDM Dispositions contained within Everton's Property.

MNDM Disposition Name	(continued)	(continued)	(continued)
D147	K1328	K268732	REG.PLAN M-574
D148	K1329	K268733	S105
D195	K1330	K2689	S109
D199	K1332	K2690	S120
D200	K1333	K2691	S124 NORTH PART
D201	K1334	K2758	S124 SOUTH PART
D202	K1335	K2759	S126
D203	K1345	K2938	S150
D204	K13464	K2978	S151
D212	K13467	K2979	S170
D213	K13544	K3014	S171
D214	K13564	K3015	S172
D215	K13565	K3018	S173
D216	k13791	K3019	S174
D217	k13792	K3026	S178
D228	k13793	K3028	S179
D228	k13794	K3029	S179
D229	k13795	K3055	S185
D233	k13796	K3056	S185
D239	k13797	K3057	S74
D265	K13802	K3058	S94
D389	k13811	K3834	S97
D493	K1395	K4395	
E264	K1396	K4396	
E270	K1627	K4431	
J.E.S.100	K1628	K4432	
J.E.S.101	K2284	K4433	
J.E.S.102	K2374 MLO	K4435	
J.E.S.103	K2458	K4436	
J.E.S.104	K2459	K6127	
J.E.S.105	K2460	K6128	
J.E.S.96	K2461	K6129	
J.E.S.97	K2462	K6130	
J.E.S.98	K2554	K6131	
J.E.S.99	K2555	K6132	
J.O.189	K2556	K6133	
K12113	K268722	K932	
K12114	K268723	M.XI	
K12115	K268724	MCA11	
K12116	K268725	MH22	
K12117	K268726	MH23	
K12118	K268727	MH24	
K12119	K268728	MH24	
K12120	K268729	MH25	
K1269	K268730	MH58	
K1317	K268731	MH59	

Table 2: Shoal Lake Property claims.

Owner	Township/ Area	Claim Number	Recording Date	Claim Due Date	Status	Percent Option	Work Required	Total Applied	Total Reserve
Everton Resources Inc.	GLASS	4249859	2009-Oct-22	2011-Oct-22	A	100%	$2,400	$0	$0
Everton Resources Inc.	GLASS	4249860	2009-Oct-22	2011-Oct-22	A	100%	$6,000	$0	$0
Everton Resources Inc.	GLASS	4249861	2009-Oct-22	2011-Oct-22	A	100%	$2,800	$0	$0
Everton Resources Inc.	GLASS	4249862	2009-Oct-22	2011-Oct-22	A	100%	$2,000	$0	$0
Everton Resources Inc.	GLASS	4249863	2009-Oct-22	2011-Oct-22	A	100%	$6,000	$0	$0
Everton Resources Inc.	GLASS	4249864	2009-Oct-22	2011-Oct-22	A	100%	$6,000	$0	$0
Everton Resources Inc.	SHOAL LAKE	4222441	2009-Oct-22	2011-Oct-22	A	100%	$1,200	$0	$0
Everton Resources Inc.	SHOAL LAKE	4249858	2009-Oct-22	2011-Oct-22	A	100%	$2,000	$0	$0
Everton Resources Inc.	SNOWSHOE BAY (SHOAL LAKE)	4224416	2008-Dec-12	2010-Dec-12	A	100%	$2,400	$0	$0
Halo Resources Ltd.	GLASS	3007239	2003-Nov-06	2010-May-06	A	100%	$331	$9,669	$0
Halo Resources Ltd.	GLASS	3007240	2003-Nov-06	2010-Nov-06	A	100%	$2,400	$12,000	$0
Halo Resources Ltd.	GLASS	3007296	2003-Nov-06	2010-May-06	A	100%	$4,800	$19,200	$0
Halo Resources Ltd.	GLASS	3007297	2003-Nov-06	2010-May-06	A	100%	$5,600	$22,400	$0
Halo Resources Ltd.	GLASS	3007299	2003-Nov-06	2010-May-06	A	100%	$6,400	$25,600	$0
Halo Resources Ltd.	GLASS	3007303	2003-Nov-06	2010-May-06	A	100%	$2,000	$8,000	$0
Halo Resources Ltd.	GLASS	3007322	2003-Nov-06	2010-May-06	A	100%	$6,000	$24,000	$0
Halo Resources Ltd.	GLASS	3007323	2003-Nov-06	2010-May-06	A	100%	$6,400	$25,600	$0
Halo Resources Ltd.	GLASS	3007324	2003-Nov-06	2010-May-06	A	100%	$4,400	$17,600	$0
Halo Resources Ltd.	GLASS	3007325	2003-Nov-06	2010-May-06	A	100%	$3,200	$12,800	$0
Halo Resources Ltd.	GLASS	3007326	2003-Nov-06	2013-Nov-06	A	100%	$800	$6,400	$2,164
Halo Resources Ltd.	GLASS	3007332	2003-Nov-06	2010-May-06	A	100%	$2,400	$9,600	$0
Halo Resources Ltd.	GLASS	3007333	2003-Nov-06	2010-May-06	A	100%	$1,471	$8,529	$0
Halo Resources Ltd.	GLASS	3007334	2003-Nov-06	2010-May-06	A	100%	$3,200	$12,800	$0
Halo Resources Ltd.	GLASS	4222450	2009-Nov-16	2011-Nov-16	A	100%	$4,800	$0	$0
Halo Resources Ltd.	GLASS	4249855	2009-Nov-06	2011-Nov-06	A	100%	$6,400	$0	$0
Halo Resources Ltd.	GLASS	4249856	2009-Nov-06	2011-Nov-06	A	100%	$4,800	$0	$0
Halo Resources Ltd.	GLASS	4249857	2009-Nov-06	2011-Nov-06	A	100%	$6,400	$0	$0

Owner	Township/ Area	Claim Number	Recording Date	Claim Due Date	Status	Percent Option	Work Required	Total Applied	Total Reserve
Halo Resources Ltd.	SNOWSHOE BAY (SHOAL LAKE)	3007250	2003-Nov-06	2010-May-06	A	100%	$2,800	$11,200	$0
Halo Resources Ltd.	SNOWSHOE BAY (SHOAL LAKE)	3007298	2003-Nov-06	2010-May-06	A	100%	$5,200	$20,800	$0
Halo Resources Ltd.	SNOWSHOE BAY (SHOAL LAKE)	3007988	2005-Dec-20	2010-Mar-22	A	100%	$8,800	$4,400	$0
Halo Resources Ltd.	SNOWSHOE BAY (SHOAL LAKE)	3007989	2005-Dec-20	2010-Mar-22	A	100%	$12,800	$6,400	$0
Halo Resources Ltd.	SNOWSHOE BAY (SHOAL LAKE)	4242852	2009-Jun-18	2011-Jun-18	A	100%	$400	$0	$0
Halo Resources Ltd.	SNOWSHOE BAY (SHOAL LAKE)	4242853	2009-Jun-18	2011-Jun-18	A	100%	$2,400	$0	$0
Halo Resources Ltd.	SNOWSHOE BAY (SHOAL LAKE)	4242856	2009-Jun-18	2011-Jun-18	A	100%	$4,800	$0	$0
Machin Mines Ltd.	GLASS	3004923	2003-Feb-03	2010-May-18	A	100%	$3,500	$8,500	$0
Machin Mines Ltd.	GLASS	4210797	2007-Apr-10	2010-Mar-22	A	100%	$3,200	$0	$0
Machin Mines Ltd.	GLASS	4219500	2008-Apr-21	2010-Apr-21	A	100%	$1,600	$0	$0
Machin Mines Ltd.	GLASS	4219501	2008-Apr-21	2010-Apr-21	A	100%	$400	$0	$0
Machin Mines Ltd.	SHOAL LAKE	1203021	2001-Oct-05	2010-Mar-31	A	100%	$1,600	$4,000	$0
Machin Mines Ltd.	SHOAL LAKE	4219502	2008-Oct-17	2010-Oct-17	A	100%	$3,200	$0	$0
Machin Mines Ltd.	SHOAL LAKE	4224383	2008-Oct-17	2010-Oct-17	A	100%	$4,800	$0	$0
Roberts, John Scott	GLASS	3019219	2006-Sep-19	2010-May-18	A	100%	$6,400	$0	$0
Roberts, John Scott	GLASS	3019221	2006-Sep-19	2010-May-18	A	100%	$2,000	$0	$0
Roberts, John Scott	GLASS	4219499	2008-Jan-23	2010-May-18	A	100%	$1,600	$0	$0

3.1 Location and Access

The Shoal Lake Property is located about 40 km west-southwest of Kenora, Ontario, which has a population of approximately 16,500. Kenora has a small airport that is serviced by daily with flights from Winnipeg and Thunder Bay. From Kenora, the Property is accessed is by driving approximately twenty-seven kilometres west of the city limits along Highway 17 and then south on Rush Bay road for approximately twenty-three kilometers to the boat launch at Clytie Bay. From there the Property can be accessed partially by land and the remainder by boat. The Property may also be reached by float equipped aircraft.

4.0 Regional Geology

The Lake of the Woods – Shoal Lake area is situated within the western portion of the Wabigoon Subprovince, and is comprised of metamorphosed Archean volcanic and sedimentary rocks which have been intruded by granitoid rocks. Some of the granitic intrusions attain batholithic dimensions, causing segmentation of the volcanic and sedimentary rocks into individual belts. The Wabigoon Subprovince is bounded to the north by the English River Subprovince, a gneissic terrain, and to the south by the Quetico Subprovince.

The margins of the Subprovinces are generally east-west, and characteristically have major breaks or fault zones developed along them. Within the central portions of these belts, as in the Shoal Lake Area, high strain zones occur around margins and between the granitic complexes. These high strain zones are favourable structural sites for gold deposits. The property described in this report is transected by a major northeast trending high strain zone which is situated between the Canoe Lake and Snowshoe Bay granitic complexes. Numerous past and future gold mines are present within this regime.

Very coarse generalized regional geology can be found in Figure 4. Geology in Figure 4 from the Ontario Geological Survey's Miscellaneous Release of Data 126-Rev.

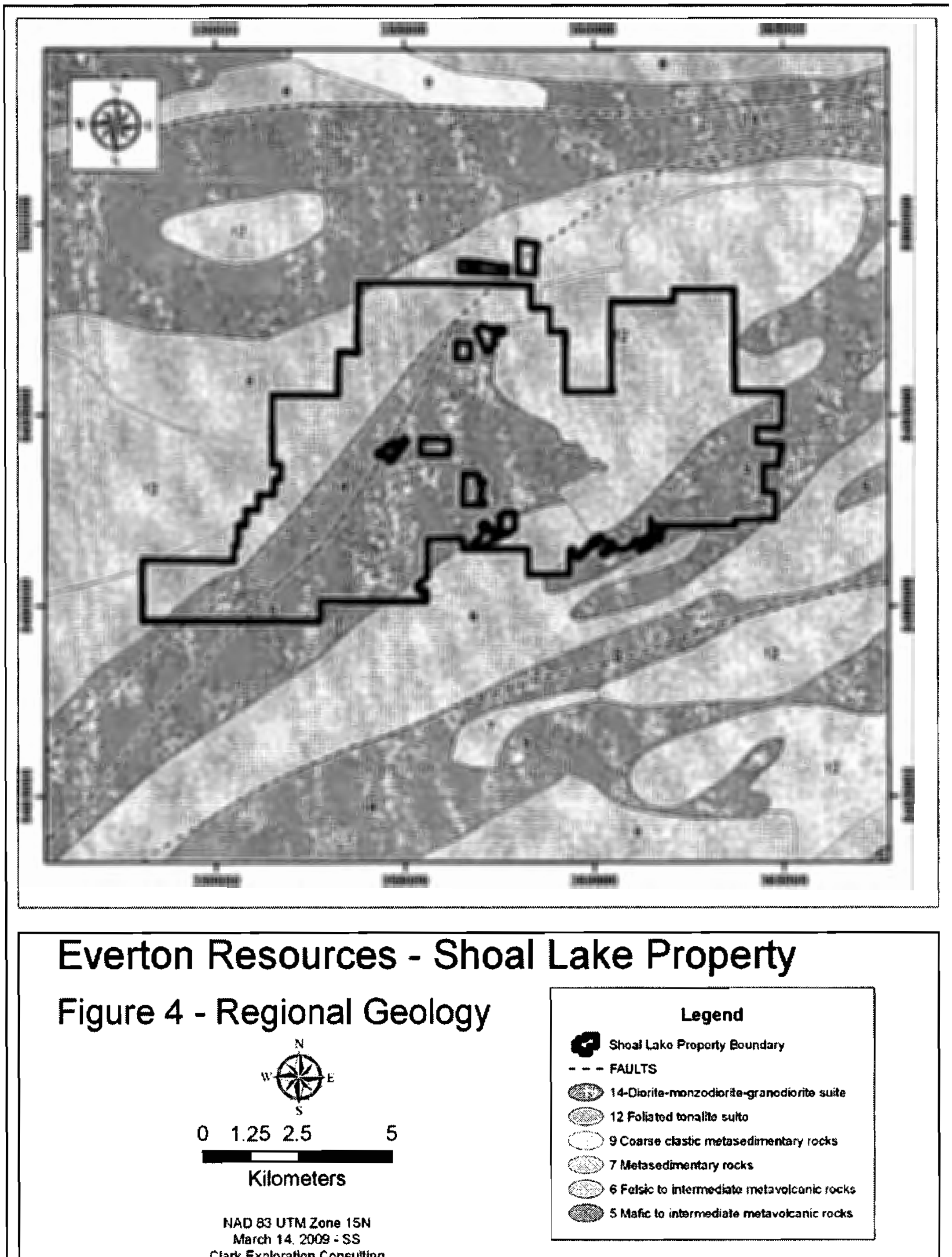

Figure 4: Coarse regional geology from MRD 126-Rev.

4.1 *Property Geology*

The following is taken from Smith (1986). Detailed regional geology is shown in Figure 5. No lithological legend is provided as these are raw images of maps M2069 and M2422 from the Ontario Geological Survey and one is referred back to them for reference. The eastern portion of the property has also been left off as the map area truncates before this boundary so there exists no data from these two map sets.

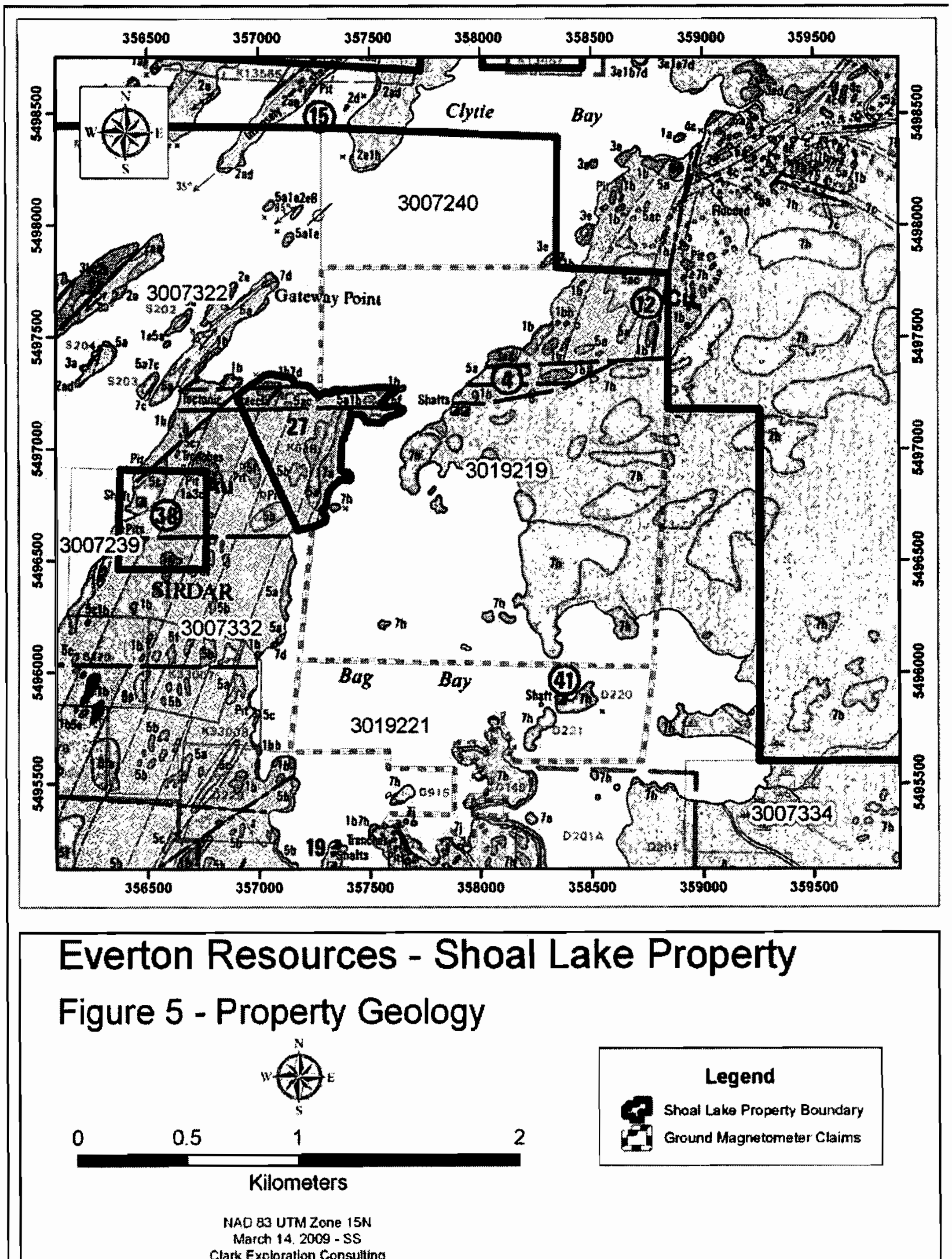

Figure 5: Detailed property geology.

"STRATIGRAPHY

Massive to pillowed feldspar-phyric basalt flows, characterized by subhedral to euhedral feldspar phenocrysts up to 5 cm in diameter, are the oldest rocks of the lower mafic-ultramafic series and act as a marker horizon. Overlying this unit are massive and pillowed aphyric basalts. Komatiitic basalt flows and ultramafic flows and/or sills overlie the aphyric basalt. A second feldspar-phyric basaltic marker unit overlies the komatiitic sequence. The nature of the feldspar phenocrysts is similar to that of the lower porphyritic unit; however, there are no pillows and the abundance and size of feldspar crystals decrease westward. Contacts are poorly exposed and it is not clear whether this unit was intrusive or extrusive. Massive and pillowed aphyric basalt overlies this second porphyritic unit to the northwest and becomes progressively more schistose in that direction.

The calc-alkaline series occupies much of the western portion of the northern Shoal Lake area. This series is characterized by dacite tuffs and tuff breccias, intercalated with andesitic tuffs and flows, basaltic tuffs and flows, reworked tuffaceous sedimentary rocks and chemical sedimentary rocks. No distinct marker units have been identified in this series. The contacts and bedding relationships are dominantly northeast trending, becoming gradually more east-northeast trending towards the west. Stratigraphic tops,determined from sedimentary rocks and pillowed basalts, are consistent with the northwest-facing, homoclinal succession observed in the lower mafic-ultramafic series.

INTRUSIVE ROCKS

A major northeast-trending, elongate diorite to quartz diorite intrusion, the Stevens Island Complex, intrudes the lower mafic-ultramafic series. The southern margin is gently curved and cuts both feldspar-phyric and aphyric basaltic flows. The southeast portion of the intrusion is characterized by medium-grained diorite with local mafic and ultramafic volcanic xenoliths and patches of primary hornblende. In places, intercalated mafic to felsic flow layers occur proximal to, and trend parallel to, the southeast contact. This layering is characterized by numerous small flow folds. No strongly defined metamorphic aureole or chill margin has been observed along the southern and eastern portion of the intrusion. To the west, the diorite is in contact with an anorthositic phase which grades northwestward into biotite quartz diorite, and in places alaskite. This apparent northwestward differentiation is consistent with the facing directions observed in the host volcanic rocks, suggesting that the intrusion may be a sill emplaced prior to the tilting of the volcanic sequence.

Several smaller, stratabound, northeast-trending felsite sills intrude the lower maficultramafic series in the northeast portion of the northern Shoal Lake area.

Two syn- to post-tectonic granitoid bodies intrude the volcanic succession. The Canoe Lake quartz diorite stock intrudes the lower mafic-ultramafic series approximately six kilometres northeast of the Shoal Lake West Project. Much of the stock is devoid of any foliation; however, a weak foliation is developed within the margin of the intrusion and several faults which have developed in the volcanics have been traced into the margin of the intrusion. The Snowshoe Bay Batholith intrudes the volcanic succession approximately one kilometre west of the Shoal Lake West Project and extends west into Manitoba. This medium-grained granodiorite intrusion is fairly homogeneous, although grain size and colour variations occur. A weak foliation or gneissosity is developed proximal and subparallel to the margins of the intrusion. This foliation appears to trend into the regional foliation, indicating that the intrusion may be syntectonic.

Quartz porphyry, quartz-feldspar porphyry and felsite dikes occur throughout the area and have been observed in a variety of crosscutting relationships. Lamprophyre dikes have been observed to cut across all lithologies, but were not recognized in either of the late intrusions.

STRUCTURE

Foliations in the Shoal Lake area tend to diverge about diapiric intrusions and form several distinctive zones of high strain. All recognized foliations are interpreted to have developed during the D2 event.

The Crowduck Lake – Witch Bay Shear Zone is a major east-trending zone of high strain tangential to the Canoe Lake Stock, Viola Lake Stock and the eastern lobe of the Dryberry Batholith. Relative horizontal movement is interpreted to be dextral. The orientation of the fabrics and the dextral sense of shear are consistent with a regional, northwesterly compression (Schwertner et al., 1979). To the south of the Crowduck Lake – Witch Bay Shear Zone, a shadow zone, in which little strain is observed, is indicated on the southwestern flank of the Canoe Lake Stock.

Several narrow, northeast-trending high strain zones occur between the Snowshoe Bay Batholith and the Canoe Lake Stock. These are developed within and along the margins of the Stevens Island Complex and trend subparallel to the intrusion boundaries. These zones of high strain define three shear zones, with similar orientations and character which suggest that each is a component of a larger deformation zone referred to as the Shoal Lake Deformation Zone. The westernmost of these shear zones contains the Duport mineralized zones and has been termed the Duport Deformation Zone. The central and eastern zones are termed the

Stevens Island Deformation Zone and Sirdar Deformation Zone, respectively (Smith, 1985).

The Duport Deformation Zone traces the contact between the lower mafic-ultramafic series and the upper felsic-intermediate series. Stratigraphic units, traceable within both the felsic-intermediate series and lower mafic-ultramafic series, are folded, truncated and deformed within the shear zone. The foliation in the Duport Deformation Zone is subvertical and trends subparallel to zone boundaries. The foliation is penetrative and is oblique or perpendicular to bedding.

Both the Stevens Island Deformation Zone and Sirdar Deformation Zone are similar to the Duport Deformation Zone. They are developed within and along the eastern margin of the Stevens Island Complex and are characterized by a strong foliation and grain size reduction. Feldspar porphyry, quartz feldspar porphyry and lamprophyre dikes are offset and truncated and in places have been deformed into fish-shaped bodies. Steep, west dipping, C and S fabrics are evident on vertical exposures and record reverse movement similar to the Duport Deformation Zone. Mineral stretching lineations pitch vertically. Pillows, where observed, are highly stretched, while quartz veins and felsic dikes are locally boudinaged.

All of the main shear zones within the northeast-trending Shoal Lake Deformation Zone indicate substantial subvertical, west-side-up movement. In places a minor sinistral component is also indicated.

METAMORPHISM

Greenschist facies metamorphic rocks are found throughout the area, characterized by a mineral assemblage of albite, epidote, chlorite, actinolite and sphene, locally with carbonate, brown biotite, quartz and sericite. An amphibolite facies metamorphic assemblage, characterized by hornblende, andesine and epidote, with or without brown biotite, garnet and anthophyllite, surrounds the felsic stocks and batholiths."

5.0 Exploration History

The exploration history of the Property is discussed at length in the 43-101 provided to Everton Resources in July of 2009 (written in November of 2008 and subsequently re-addressed) by Scott Wilson RPA Inc. This 43-101 focuses on the Shoal Lake West portion of the property which encompasses the Duport Mine. The Mikado and Cedar Island mines which are assumed to make up a Shoal Lake East property of which there exists no 43-101 are therefore lacking in detail with regard to exploration history.

The following is taken verbatim from Valliant and Chamois (2008) of Scott Wilson RPA.

"Activities began on the Shoal Lake West property as early as 1897.

From 1897 to 1900, Cameron Island Mining explored four quartz veins on Cameron Island. Work included extensive surface stripping, a 6.1 m (20 ft.) open cut on the No. 1vein, a 9.1 m (30 ft.) open cut on the No. 2 vein, a 40.2 m (132 ft.) inclined shaft, test pits on the No. 3 and No. 4 veins, and a 20.1 m (66 ft.) adit on the eastern shore of the island to intersect the No. 1 and No. 2 veins. From

1903 to 1904, a ten-stamp mill was constructed.

From 1910 to 1912, Cameron Island Syndicate dewatered the shaft and resumed underground work. A mill run was made, but details are unavailable. In 1915, Cameron Island Syndicate extended the lateral workings to 148.7 m (488 ft.) on the 20.4 (67 ft.)and 38.7 m (127 ft.) levels. A small stope on the second level was worked to a height of 6.1 m (20 ft.). A five-ton mill run graded 0.48 oz/ton Au and 1.2 oz/ton Ag.

From 1933 to 1936, Duport Mining drilled several holes from surface, dewatered the shaft and sank a 74.7 m (245 ft.) inclined winze from the second level. Additional levels were driven at 68.3 m (224 ft.) and 112.5 m (369 ft.) depth. Lateral development totaled 713.5 m (2,341 ft.), with 25.3 m (83 ft.) of raising and some stoping on the second level. Duport Mining produced 1,100 tonnes of material, grading 115 g/t Au, which was shipped to smelters at Tacoma, Washington, and Flin Flon, Manitoba, for processing during the period 1934-1936.

From 1950 to 1951, Matachewan completed an electromagnetic survey, 8,773 m of surface and underground drilling, and 360 m (1,180 ft.) of trenching. The shaft was dewatered and 9.8 m (32 ft.) of raising was completed on the second level.

From 1965 to 1967, Westfield extended the known gold-bearing zones both laterally and vertically by completing 3,516 m of surface diamond drilling.

CPM carried out an initial program of exploration in 1973 consisting of dewatering the shaft and taking bulk samples from the second level.

In 1982, Selco optioned the property and completed airborne and ground geophysical surveys, as well as 9,373 m of drilling.

From 1983 to 1985, Union Carbide optioned the property and completed drilling and underground exploration from a new 1,185 m underground decline driven fromStevens Island. The decline intersected the mineralized zones on the 99.1 m (325 ft.),134.1 m (440 ft.) and 158.5 m (520 ft.) levels. Drifting was done to the north and south on the East and the Main zones on the 99.1 m (325 ft.) level and on the Main Zone on the 158.5 m (520 ft.) level. Bulk and channel samples were taken from all levels. The program confirmed the presence of a mineral resource and led to the extension of known geological structures along strike to the northeast and southwest.

CPM continued underground development on the property during 1986 and 1987 with a program to further define the extent of the gold-bearing horizon. The program included extending the existing decline to a vertical depth of 200 m and diamond drilling, to establish continuity of the gold-bearing horizon to 500 m below surface. Three raises were driven in mineralized material and a 90-tonne bulk sample was mined and shipped to Lakefield Research, Lakefield, Ontario, for pilot plant metallurgical testing. Based on the resultant resource estimate and metallurgical work, CPM commissioned Wright Engineers Ltd. (Wright) to conduct a feasibility study in 1988.

During the time the Wright study was being prepared, CPM commenced the formalpermitting process. The most important aspect of the potential environmental impact of proposed mine development was its location on Shoal Lake. Shoal Lake is the source of drinking water for the city of Winnipeg, Manitoba, and is also the location of two First Nations communities and a number of seasonal cottages. CPM recognized very early during its ownership of the property that environmental concerns regarding development and operation of the property were important.

Between 1979 and 1988, CPM collected baseline environmental data and commissioned Agra Earth & Environmental Ltd. to study the issues and prepare an environmental impact study. The design for plant andinfrastructure was intended to mitigate any environmental effects of the operation.

Despite the fact that the technical aspects of the environmental management plan were relatively straightforward, the property received considerable scrutiny from the local cottagers and, eventually, the city of Winnipeg and the province of Manitoba. The public perceptions were such that in 1989 the Ontario permitting process was stopped and the property was designated for review under the Canadian Environmental Assessment Act.

From 1989 to 1993, essentially no activity took place on any aspect of the property.

From 1988 to 1990, Exploration Brex Inc. (Brex) completed preliminary geological and geophysical surveys on a 40-claim property located immediately east and northeast of Stevens Island, culminating in a four hole drill program totalling 672 m. Brex's property is now incorporated within the Shoal Lake West property. A 68.4 km linekilometre grid was established and surveyed with ground magnetics and VLF-EM.

Geological mapping and sampling of the islands resulted in a number of surface showings generally consisting of narrow quartz vein related mineralization within the Stevens Island Deformation Zone. Grab samples from these showings are reported to have assayed up to 87.45 g/t Au. A boulder of massive arsenopyrite from Seahorse Island yielded 6.62 g/t Au. Holes SL-89-02 and SL-90-4, drilled 115 apart and immediatelynorth of Stevens Island, intersected significant mineralization consisting of pyrite,chalcopyrite and arsenopyrite bearing quartz veining within talc-chlorite schist. SL-89-02intersected values of 8.30 g/t Au across 2.95 m (167.94 m to 170.89 m), 6.45 g/t Au across 1.05 m (186.70 m to 187.75 m), and 12.66 g/t Au across 1.85 m (190.42 m to 192.27 m) (Yeomans, 1989). Hole SL-90-04 intersected 4.00 g/t Au across 3.24 m (36.49m to 39.73 m) (Yeomans, 1990).

Commencing in 1993, CPM reactivated the environmental aspects of the property with the objective of restarting the approval process. As a first step, the property development plan was significantly revised from the Wright study in that all processing was moved to a location outside the Shoal Lake watershed. Ore was to be mined on Stevens Island and hauled by truck to the proposed plant site approximately 10 km away on the mainland. Two processing options were considered – production of concentrate at the plant followed by gold recovery at Placer Dome's Campbell Mine in Red Lake, and production of gold at the plant. The former option had the advantage of eliminating the use of cyanide in the Shoal Lake area. No physical or technical work was carried out on the property during this time other than environmental baseline work and minor fieldwork in support of the revised property development plan.

During this time, CPM re-established a working relationship with the two First Nations on Shoal Lake. An extensive program of community relations was carried out including workshops and public consultation sessions in the communities. Impact and Benefit Agreements were signed with both communities. CPM also implemented a buyout program with affected cottagers on Shoal Lake. Outside the area, CPM carried out extensive consultations with key officials at the city of Winnipeg, the provinces of Manitoba and Ontario, and the federal government in order to describe the revised project and to establish the process for formal environmental approval.

In 1996, after acquiring CPM, ROM updated the CPM work and initiated an internal feasibility study based on CPM's revised development plan. Instead of using theCampbell Red Lake option, concentrate was to be railed to the ROM plant in Timmins, Ontario, where it would be treated using a bio-oxidation process. ROM did not carry out any physical work on the site other than a limited diamond drilling program during 1996-1997. The logs corresponding to ROM's drilling are not available.

In 2005, Halo initiated a comprehensive exploration program consisting of ground and airborne geophysics and diamond drilling. From February 18 to March 28, 2005, Halo completed a total of 70 line kilometres of ground magnetometer surveying over three grids in order to gain geological and structural information for the purpose of locating drill holes. The grids were located i) north of Stevens Island (North Grid), ii) over the southern portion of Stevens Island (East Grid), and iii) over the western portion of Dominique Island (South Grid).

Halo's North Grid covered a portion of the area of the 1988 Brex survey. The survey was successful in delineating contacts between contrasting lithologies in areas of known gold mineralization. The survey, however, did not include the area of the Duport deposit itself and the coverage was insufficient to cover potential targets north of Stevens Island and in the vicinity of Dominique Island.

From August 15 to September 2, 2005, Fugro Airborne Surveys (Fugro) completed 2,743 line kilometres of combined magnetic and electromagnetic helicopter-borne survey under contract to Halo. The survey was flown at 50 m and 100 m line spacings using Fugro's DIGHEM multi-coil, multi-frequency electromagnetic system and a highsensitivity cesium magnetometer. The objective was to identify altered shear zones containing sulphides related to fault structures, intrusive bodies, and competency contrasts between lithologies.

Several magnetic signatures similar to those observed at the Duport deposit were defined. The contoured magnetic data outlined a predominantly north-northeast fabric to the structural and lithological components of the Shoal Lake greenstone assemblage. Distinctive lenticular to elongate magnetic lows striking north-northeast across the centre of the survey area were interpreted to reflect either felsic lithologies in the core of the assemblage or a thick pile of dominantly metasedimentary rocks. A series of ovoid or annular features were interpreted to represent folded and faulted metavolcanic rocks. Three northeast to north-northeast trending deformation zones were interpreted. A considerable number of weak to moderate conductive features were defined in the electromagnetic data, most displaying north-northeast orientations parallel to the regional fabric.

Fifteen targets consisting of conductive features within a one kilometre wide band north-northeast and south-southwest of the Duport deposit were identified for follow-up. These targets have yet to be drill tested.

During the winter of 2005, Halo completed a 23-hole, 7,054 m drilling program from the ice on Shoal Lake. The holes were drilled perpendicular to the strike of the mineralized zones at dips varying from -45° to -67°. Two holes (2005-1 and 2005-2) were drilled to confirm historical resources. Nineteen holes (2005-3 to 2005-19 and 2005-21 to 2005-23) were drilled on a 30 m to 100 m spacing over a strike extension of approximately one kilometre to test the downward and/or southern extension of historical resources. One hole (2005-20) was drilled to test for possible mineralization in a structural feature indicated by the ground magnetic survey. The program confirmed the presence of high-grade gold mineralization as reported in previous studies and confirmed the extension of gold structures along strike and down dip from previous resources, albeit mainly at sub-economic grades."

6.0 2010 Ground Magnetometer Survey

Clark Exploration Consulting was contracted in February-March, 2010 to conduct a 25m line-spaced ground magnetometer survey over a portion of Shoal Lake. A total of 52.8 line-km of cesium ground magnetometer were performed from February 28, 2010 to March 6, 2010. Figure 6 shows the gridlines for the survey along with claim boundaries. Claim K3019219 contained the entirety of the completed survey.

The focus of the exploration was on an area of the Shoal Lake Deformation Zone (SLDZ) where a large flexure occurs. Observable in airborne magnetics, this flexure was mapped in 1990 as an east-west trending shear zone containing 4 gold occurrences within 1500 meters of strike. The ground magnetometer survey was designed to test the detailed geophysical response in the area of the flexure to try and pickup features that may not have been realized in the airborne survey.

The survey was done on the ice using a snowmobile and non-ferrous dog-sled carrying a geophysical technician wearing a Geometrics G-859 'back-pack' cesium-vapour magnetometer. A Geometrics G-856AX proton precession magnetometer was used as a base station for measuring and correction for diurnal variation. Both the magnetometer and base station were rented from Kivi Geoscience of Thunder Bay, Ontario. An overview of each device is provided below, and details on both of the instruments and their specifications are provided in Appendices A (G-856AX) and B (G-859) in the form of manuals. Due to problems with the navigating GPS on the snowmobile some lines in the southernmost portion of the grid deviated from the 25-m line spacing. Lines could not be done after this was discovered as rain and abnormally warm weather has made the shoreline at Shoal Lake unsafe to pass thereby making the lake inaccessible. Figures 7 and 8 are images showing the Total Field and 1st Vertical Derivative grids obtained in the survey.

Post-processing and gridding was carried out by consulting geophysisict Monika Sumara and Geosoft grids of Total Field Magnetics and First Vertical Derivative are included as maps in Appendix C of this report.

6.1 General Device Specifications

<u>G-856AX</u>

The G-856 provides a reliable, low cost solution for a variety of magnetic search and mapping applications. Single key stroke operation means the G-856AX can be operated by non-technical field personnel or used in teaching environments. The G-856AX uses the well proven proton precession technology, allowing accurate measurements to be made with virtually no dependence upon variables such as sensor orientation, temperature, or location. The unit provides a repeatable absolute total field magnetic reading, traceable to the National Bureau of Standards.

Applications:

The principle application for the G-856AX is as a base station system for monitoring and recording of the Earth's diurnal magnetic field variation. These base station measurements are downloaded into MagMap2000 for automatic correction of G-865AX, G-858 or airborne survey data. Base station accessories available for use with the G-856 include external power cable and base station tripod kit.

The G-856AX is also used in mapping geological structures, for mineral exploration, magnetic search for industrial, environmental or archaeological targets. The optional gradiometer attachment gives greater resolution and noise immunity for conducting searches in industrial or high cultural noise environments. Simple operation, large digital data storage capability, and the inclusion of MagMap2000 data transfer and editing software provides a system well suited for both teaching and survey applications.

A thoroughly well proven design (over 2,500 units sold), excellent performance and the lowest price professional system are key features of the G-856AX. Combined with the ease of use, user friendly download/editing software, and readily available commercial contouring programs, the G-856AX represents a complete magnetic surveying package generating high quality data for budget conscious users.

Specifications:

- Resolution: 0.1 nT
- Accuracy : 0.5 nT
- Clock: Julian date, accuracy 5 sec per month.
- Tuning: Auto or manual, range 20,000 to 90,000 nT
- Gradient Tolerance: 1000 nT/meter
- Cycle time:3 sec to 999 sec standard , can be manually selected as fast as 1.5 sec cycle time.
- Read: Manual, or auto cycle for base station use.
- Memory: 5700 field or 12500 base station readings
- Display: Six digit display of field/time, three digit auxiliary display of line number, day

- Digital Output: RS-232, 9600 baud.
- Input: Will accept external cycle command.
- Physical Console: 7 × 10.5 × 3.5 inches, (18 × 27 × 9 cm) 6 lbs (2.7 kg)
- Sensor: 3.5 × 5 inches (9 × 13 cm) 4 lbs (1.8 kg
- Environmental: Meets specifications within 0 to 40 C
  Will operate satisfactorily from -20 to 50 C
- Power: Rechargeable, magnetically compensated Gel-Cel batteries

<u>G-859</u>

A Professional Magnetic Mapping System For Minerals, Petroleum and Geologic Surveys

- Excellent Performance: Low Noise/High Sensitivity, best in the industry – 0.008nT/Hz RMS – and world-wide operation
- Very Fast – Log mag and GPS at up to 5 samples per second for economic large area surveys at high sample density
- Integrated GPS/Backpack – Includes non-magnetic backpack and Novatel™ WAAS / EGNOS ready GPS
- Low AC Field Interference – Best in the industry for rejecting AC power line grid noise (50/60 Hz)
- Easy-to-use – Simple setup and rapid in-field map generation with free MagMap2000™ software
- Reliability – Our Cesium sensors never need calibration or factory realignment. Designed for extreme ruggedness and reliability.
- Designed for large surveys mining/oil/gas – This versatile tool is specially designed for large area surveys with 8 hr data storage capacity and two 6 hr battery packs

This new low-cost Cesium vapor magnetometer system offers the mining/oil/gas survey companies the best total field magnetic survey tool available. Based on our industry standard G-858 MagMapper system, the G-859 incorporates all of the reliability and proven performance in a lightweight survey package with integrated WAAS/EGNOS enabled Novatel™ GPS.

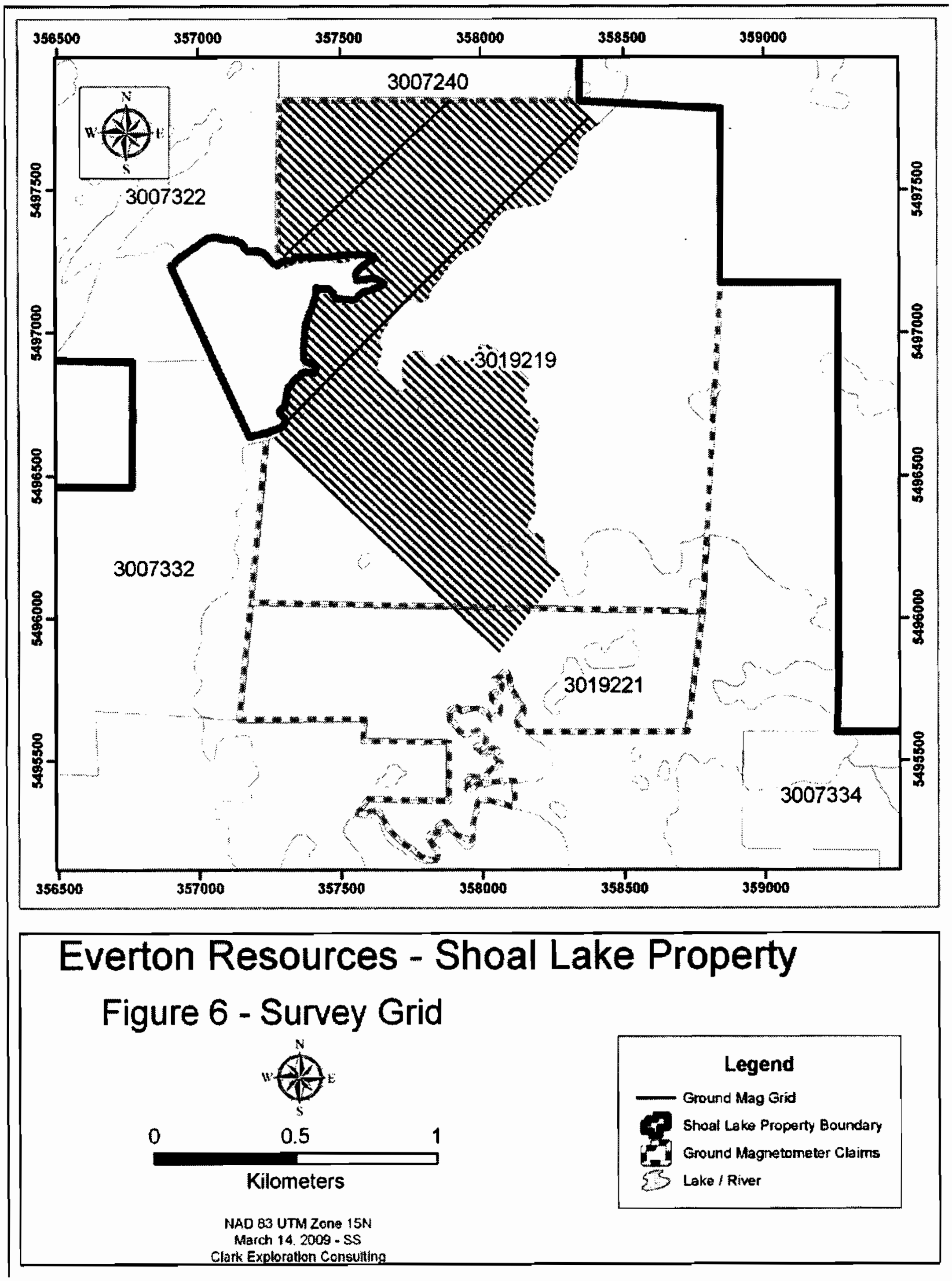

Figure 6: Ground magnetometer survey grid.

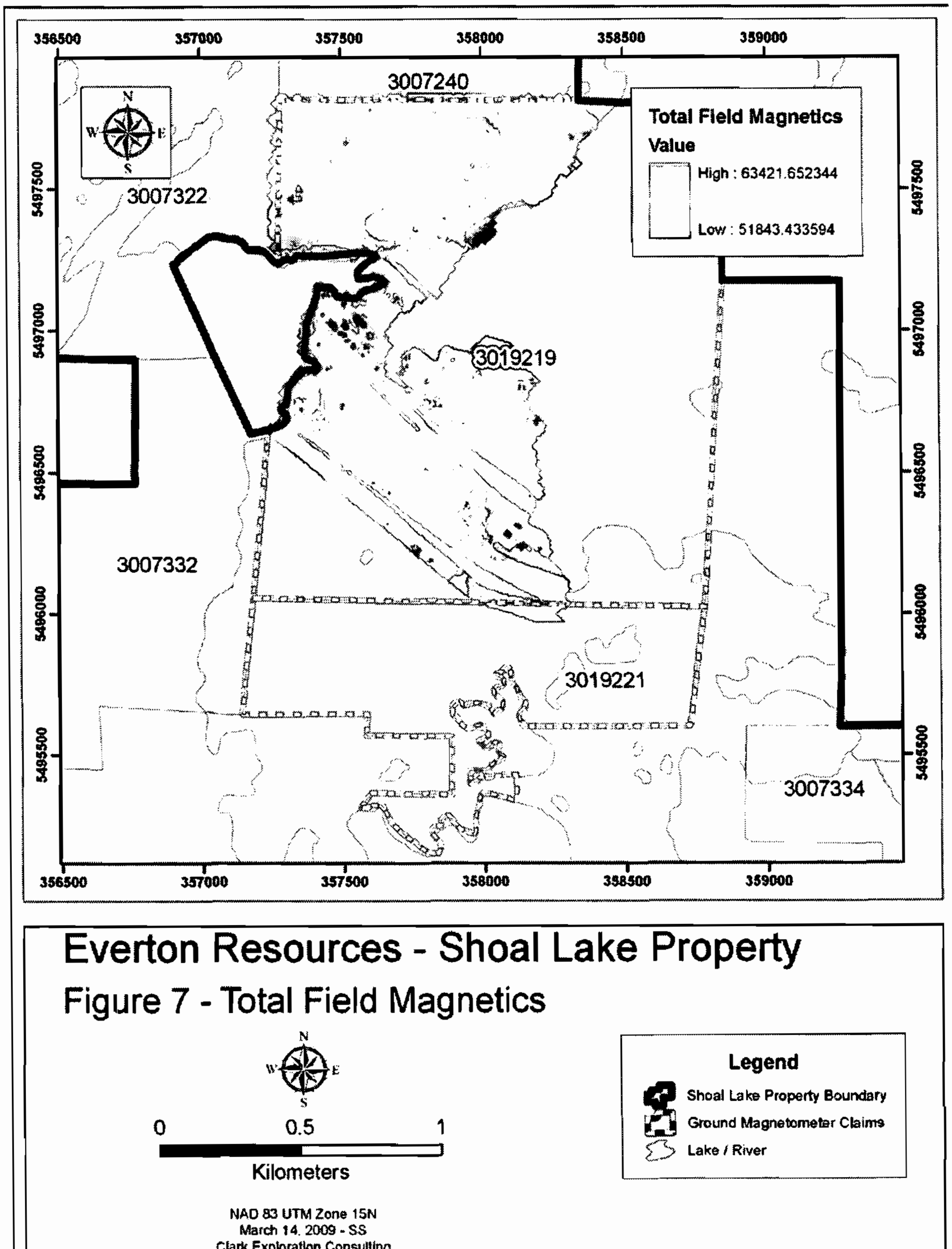

Figure 7: Total field magnetics.

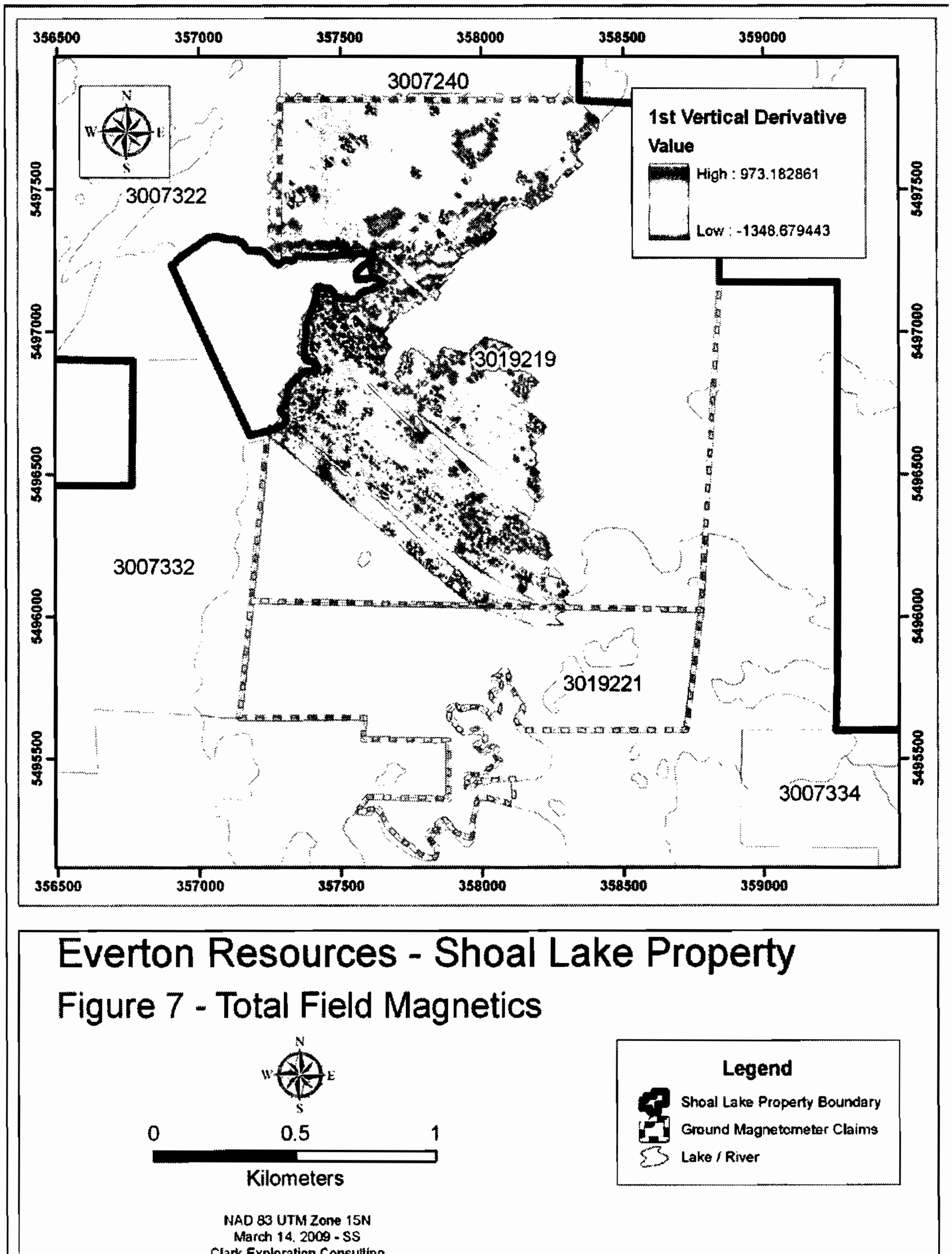

Figure 8: First vertical derivative.

7.0 Conclusions and Recommendations

While the survey was completed successfully, features that would be interpreted as structures representing second-order splays and zones of dilation were not recognized. Ground magnetics should be obtained for deviated lines in the southern portion of the survey, along with the eastern portion of the peninsula and stitched to the existing grid to help visualize the relationship to the gold showings.

8.0 References

Beakhouse, G.P., 1991: Winnipeg River Subprovince *in* Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 1, pp. 279-301.

Blackburn, C.E., Johns, G.W., Ayer, J. and Davis, D.W., 1991: Wabigoon Subprovince *in* Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 1, pp 303-381.

Davies, J.C. and Smith, P.M., 1988: The Geological Setting of Gold Occurrences in the Lake of the Woods Area. Ontario Geological Survey, Open File Report 5695, 381 p.

Davies, J.C., and Smith, P.M., 1984: The structural and stratigraphic control of gold in the Lake of the Woods area *in* Summary of Field Work, 1984, Ontario Geological Survey, Ontario Geological Survey Miscellaneous Paper 119, pp. 185-193.

Davies, J.C., 1965: Ewart-Forgie Area, Ontario Geological Survey, Map 2069, Precambrian Geology Series. Scale 1 inch to ½ mile, 1:31:680. Geology 1961, 1962.

Davies, J.C., 1982: Bag Bay, Ontario Geological Survey, Map 2422, Precambrian Geology Series. Scale 1 inch to ½ mile, 1:31:680. Geology 1968, 1969.

Giroux Consultants Ltd., 2003: A Resource Estimate on the KPM Shoal Lake Project: Private report for Amador Gold Corp.

Kilborn Engineering Pacific Ltd., 1996: Bio-Oxidation Prefeasibility Study, Duport Project: Private report for Royal Oak Mines Ltd.

Schwertner, W.M., Stone, D., Osadetz, K., Morgan, J., and Stott, G.M., 1979: Granitoid complexes and the Archean tectonic record in the southern part of Northwestern Ontario, Canadian Journal of Earth Sciences, v. 16, pp. 1965-1977.

Smith, P.M., 1986: Duport, A Structurally Controlled Gold Deposit in Northwestern Ontario, Canada *in* A. James Macdonald, ed., Proceedings Volume, Gold '86 An International Symposium on the Geology of Gold Deposits, pp 197-212.

Smith, P.M., 1985: Geological setting of the Duport Gold Mine, Shoal Lake, District of Kenora, *in* Wood, J., et al., eds., Summary of Field Work and Other Activities, 1985, Ontario Geological Survey. Ontario Geological Survey Miscellaneous Paper, pp. 210-214.

Strathcona Mineral Services, 1989: Gold Recovery from Flotation Concentrate, Process and Design Review Based on Pilot Plant Investigation: Private report for Consolidated Professor Mines Ltd.

Strathcona Mineral Services, 1988: Ore Reserve Audit, Duport Deposit: Private report for Consolidated Professor Mines Ltd. Troop, Andrew J., 1989: Geology, Geochemistry, Diamond Drilling, Underground Exploration and Geological Mineral Reserves of the Duport Gold Property: Private report for Consolidated Professor Mines Ltd.

Turner, J.A. and Leonard, K.W., 2004: KPM Property, Northwestern Ontario 2004 Exploration Report. Report prepared for Amador Gold Corp. SEDAR.

Valliant, W.W and Chamois, P., 2008: Technical Report on the Shoal Lake West Project, Northwestern Ontario, Canada. NI 43-101 Report prepared for Hays Lake Gold Inc. by Roscoe Postle Associates Inc.

Wright Engineers Limited, 1988: Duport Gold Mine, Feasibility Report: Private report for Consolidated Professor Mines Ltd.

Yeomans, W.C., 1989: Results of a Gold Exploration and Drilling Program. 162278 Canada Inc. Option, Shoal Lake Property (Ewart Township, Kenora District). Private report for Exploration Brex Inc.

Yeomans, W.C., 1990: Results of a Drilling Program. 162278 Canada Inc. Option, Shoal Lake Property (Ewart Township, Kenora District). Private report for Exploration Brex Inc.

Appendices

Appendix A

G-856 Manual

G-856 Memory-Mag™

Proton Precession Magnetometer

OPERATOR'S MANUAL

P/N 18101-02

GEOMETRICS, INC.

2190 Fortune Drive, San Jose, CA 95131
Phone: (408) 954-0522
Fax: (408) 954-0902
Eml: sales@mail.geometrics.com
Web: www.geometrics.com

DECLARATION OF CONFORMITY

We, Geometrics, Inc.
Geometrics Europe
2190 Fortune Drive
San Jose, CA 95131 USA
phone: (408) 954-0522
fax: (408) 954-0902

declare under our sole responsibility that our portable magnetometers, models G-856, and G-856G to which this declaration relates are in conformity with the following standards:

EN 55022: 1995, EN50082-2: 1995, ENV 50140: 1994, ENV 50141: 1994,
EN 61000-4-2: 1995, EN 61000-444: 1995

per the provision of the **Electromagnetic Compatibility Directive *89/336/EEC*** of May 1989 as Amended by ***92/31/EEC*** of 28 April 1992 and ***93/68-EEC, Article 5*** of 22 July 1993.

The Technical documentation required by Annex IV(3) of the Low Voltage Directive is maintained by Christopher Leech of Geometrics Europe (address below).

The authorized representative located within the Community is:

Geometrics Europe
Christopher Leech
Manor Farm Cottage
Galley Lane
Great Brickhill
Bucks. MK17 9AB, U.K. ph: +44 1525 261874. FAX: +44 1525 261867

Mark Prouty, President
Geometrics, Inc.
San Jose, CA, USA

TECHNICAL MEMO

NOTE TO NEW G-856AX USERS

The G-856AX Portable Proton Precession Magnetometer is a versatile rugged tool for locating buried ferromagnetic targets. However, the device has some limitations when used in **high magnetic field gradients** or near power lines which generate **electromagnetic field interference.**

If the signal-to-noise ratio is low (due to gradients or rapidly changing fields due to proximity to large steel objects like a car or AC Powerline) the G-856AX Magnetometer will respond with 5 quick beeps just prior to the display of the data. Also, the "tenths" of gammas digit will be truncated (missing) under these conditions. ***This is an indication of an error condition usually attributable to high gradients or AC interference.*** Here are some techniques that can be employed to maximize the performance of the magnetometer:

1) Make sure that the magnetometer is properly tuned and that you are getting maximum tuning signal values. See the section on tuning the magnetometer (page 9).

2) Remove the magnetometer from the area where it is getting "high gradient" beeps and see if it performs correctly. If so, **remove the rear cover and turn Switch 3 "Short Count Gate" to the "ON" position** and try it again in the problem area. This switch causes the magnetometer to generate 0.2 gamma data compared to 0.1 gamma data, but in high gradients, this slight change is of no importance. However, it will also improve the signal-to-noise ratio by keeping the read cycle to the early "strong" portion of the signal generation. See page 37 for more discussion.

3) If you still get the occasional beep, you can strengthen the signal further by increasing the polarize time. This is done by turning **Switch 1 (Long Pol) to the "ON" position.** However, this has the adverse side effect of increasing the cycle time and draining the batteries more rapidly. See page 37.

4) If you are still getting errors, we suggest that you try raising the sensor to a higher altitude, thus moving it to a lower gradient area. Make sure the sensor is properly oriented (north).

5) Make sure the batteries are fresh and that the cable is not damaged or "open". If problems persist, please contact Customer Service at (408) 954-0522 or support@mail.geometrics.com

G-856 Front Panel Keys

CLEAR

Clears a key stroke or key stroke sequence.

SHIFT

Accesses the numbers on the keys rather then the function.

ENTER

Designates the end of a key sequence and transfers command to system. Also increments memory location displayed during recall operations (see RECALL).

OUTPUT

Begins automatic output of data to external device.

AUTO

Starts and stops automatic recording mode. Sets interval for automatic recording

ERASE

Erases a reading, the last group of readings, or the whole memory. (Must depress twice).

FIELD

Used during memory recall to recover the field reading after TIME has been depressed.

TIME

Accesses the real time clock. Also displays the time at which readings were taken.

TUNE

Displays and/or sets the tuning. Provides display of the signal strength received from last reading

RECALL

Accesses the memory. Also decrements the memory location displayed

STORE

Stores reading in memory

READ

Takes a measure of the magnetic field.

G-856 Front Panel Displays

FIELD/TIME

Displays the magnetic field or the time

STATION/DAY

Displays the station number, also the Julian Day, or the line number. Also displays signal strength, tuning and battery voltage.

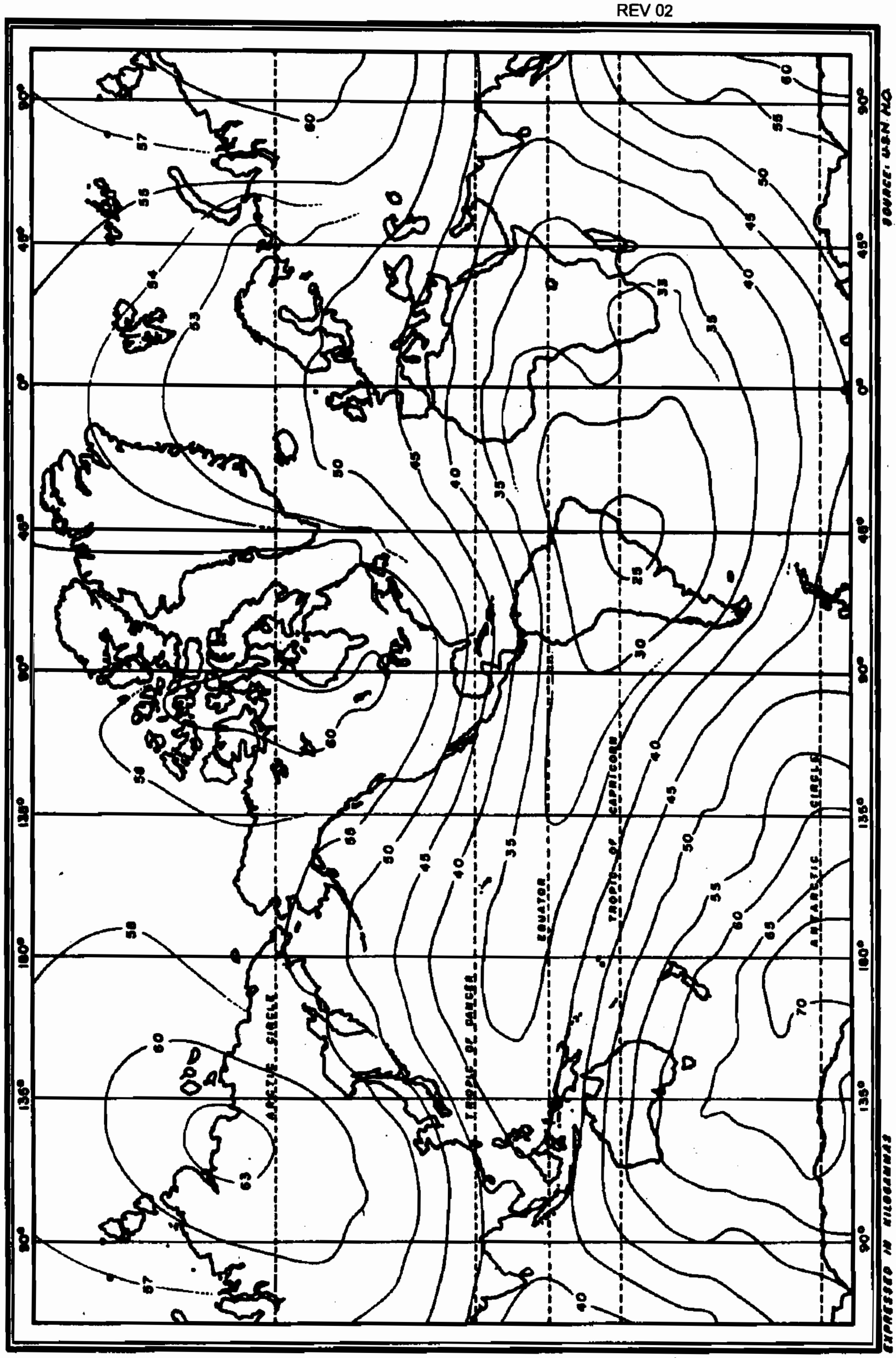
ARCTIC CIRCLE
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
ANTARCTIC CIRCLE

Table of Contents

Preface

What is a Magnetometer?

A magnetometer is an instrument for measuring the intensity of the earth's magnetic field. Most rocks contain some magnetite, the most common magnetic mineral, and therefore produce some disturbances in the local magnetic field. Soils and many man made objects such as pottery and pipes can have magnetic properties detectable by the magnetometer.

Through interpretation of magnetometer readings, assumptions can be made about what exists beneath the surface, whether it is a pipeline, an ancient urn, a piece of ordnance, a particular mineral, or geologic structure. The interpretation of magnetic data received from a magnetometer is sometimes a difficult task, made even more complex by constant changes in the earth's overall magnetic field, the size and distance of objects from the magnetometer, the amount of magnetic material the object contains, and the susceptibility of the object to absorb magnetism from other sources. On the other hand, many applications may require only simple interpretations of anomalies.

The proton precession magnetometer is one of the principal instruments for magnetic studies because it combines high accuracy and ease of use. The Applications Manual for Portable Magnetometers, supplied with this instrument and available for download from our website includes general information on the use of magnetometers. It should be studied as a companion to this volume, which deals specifically with the G-856AX Memory Mag™ Proton Precession Magnetometer.

The G-856

The G-856 is a portable, man-carried magnetometer/gradiometer and a "base station" magnetometer. As a hand-carried instrument, it features simple, push button operation and a built-in digital memory which stores over 5000 readings. This relieves the user of the need to physically write down the data in the field, eliminates transcription errors and most importantly, allows the use computers to automatically record and process the data from the magnetic survey. A number of programs are supplied by Geometrics at no cost to help the user interpret the data (see and download MagMap2000 and MagPick from our website www.geometrics.com).

The G-856 Memory-Mag magnetometer will also record automatically at regular intervals, so it can be left unattended to monitor diurnal changes in the earth's magnetic field. These readings (up to 12,500) are used to correct simultaneous field measurements for high accuracy surveys. Here again, the data may be fed directly into a computer so that the field data taken with an identical G-856 or G-858 MagMapper™ may be automatically corrected. The time-of-day is recorded with each reading taken in either mode from a built-in digital clock.

All operations are controlled from a weatherproof membrane switch front panel. The sequence of operations was carefully designed to be very simple to operate and yet flexible. Erasing the memory requires a fail-safe sequence to protect the data, except for the most recent reading which can be easily deleted and replaced if desired.

A single connector is used for the sensor and data output. The output format is in the universal RS-232, understood by computers. Interface software for downloading, profiling and gridding/contouring of data is supplied at no charge (MagMap2000).

Physically, the G-856 is compact and lightweight. It is weather proof and operates over a wide temperature range. It is powered by nine D-cell batteries, sufficient for about 3000 readings, or an internal rechargeable lead acid gel cell battery (camcorder type).

An internal programming switch allows modification of the cycle times to ensure that the G-856 works properly near the magnetic equator and in high gradients where other models may operate only marginally or fail to obtain reliable data.

Above all, the G-856 is a high-precision magnetometer, the result of many years experience in the manufacture of similar instruments. The operation of the instrument is controlled by a microprocessor and the control program may be changed at any time for product improvement or other considerations. In that event, you may find variations between this manual and the operation of your actual instrument operation. Such variations will have no adverse effect and should be recognizable as you familiarize yourself with operation.

Use of the G-856AX as a Gradiometer

A separate addendum has been added to the rear of this manual that describes the use of the G-856 as a Vertical Gradiometer. The gradiometer provides increased detection and enhancement of anomalies due to objects at a distance of up to 5 times the separation of the sensors. It also inherently removes diurnal variations due to the solar flux of charged particles interacting with the Earth's magnetic field.

Contents of this Manual

This manual presents the operating instructions for the G-856. Included are step-by-step instructions on how to:

*operate the magnetometer

*use the special features in surveying

*retrieve data

*maintain the magnetometer

Clarification of Terms

The terms used to describe the actions of the operator or functions of the magnetometer may be new to some users. For example, the areas or buttons, on the front panel will be called "keys". The words "sampling", "cycling", and "taking a reading" are all synonymous, and "mode" is used to refer to different parts of the magnetometer's operation, its different capabilities. The G-856 has two parts of operation--auto (automatic) mode and survey mode (regular field operation where the operator pushes buttons to take a reading).

There are two functions on most keys. When accessing the numbers on the keys, the magnetometer is said to be in numeric mode. When using a key to exercise a command (e.g. TUNE), the magnetometer is said to be in the command mode.

Chapter 1

Initial Set-up

This part of the manual contains information operation of the G-856 and use of its accessories. There is a separate addendum at the end of this manual which describes the use of the G-856 as a gradiometer or two sensor system.

The G-856 comes packed in a strong ABS plastic suitcase, with compartments for its accessories. It contains:

*the G-856 magnetometer

*a sensor

*a collapsible aluminum staff

*a signal cable

*a chest harness

*two sets of 9 D-cell batteries (or 2 rechargeable lead acid battery packs)

*G-856 Operator's Manual

*Application Manual for Portable Magnetometers

*MagMap2000 Software and Manual

*RS232 Data Output Cable

A. System Checkout

This procedure is to check the magnetometer's operation and to familiarize you with the system. Note that the magnetometer will produce incorrect readings indoors or where magnetic interference (from buildings, power lines, vehicles, etc.) is present.

1) Assemble the staff by inserting each section into the next and twisting to lock them together.
2) *Fill the sensor with fluid if shipped empty. Shake the sensor to determine if fluid is installed. A sloshing sound indicates proper filling (some air space is proper for expansion, see instructions on page 27.)
3) Mount the sensor (the white cylindrical object on the staff by screwing the staff into the threaded sensor mount. You'll notice there are two ways the sensor can be mounted, either on its end or horizontally. Mount it vertically now. We will discuss the horizontal method (also called saddle-mount) in Chapter 2. As an alternative, the sensor and magnetometer may be carried in the chest harness.
4) Using the signal cable, connect the sensor to the magnetometer.
5) Depress READ. The displays will light, turn off, then light again for 5 seconds. If the displays did not light, see the maintenance and Troubleshooting section in Chapter 4.

B. Operation Procedure

This section will show you how to take a reading, store it, and recall it from memory. After you've seen the general way in which the G-856 functions, the next section will begin the step-by-step instructions on operation.

The G-856 is really quite simple to operate. Most of the controls will not be used during the course of a normal survey and much of the sequence is automatic. The READ and STORE sequence is all you usually need.

To take a reading of the magnetic field, store it, and recall it from memory will require the use of, three keys.

READ 9	STORE 8	RECALL 7
(1)	(2)	(3)

1. When you depress READ, the displays will light briefly with the battery voltage, for example:

batt	FIELD/TIME
11 . 7	STATION/DAY

2. Then, the battery voltage will go out. After a short interval, the FIELD/TIME display will light with a 5 or 6 digit number, for example:

67584 . 2	FIELD/TIME

   This is the magnetic field reading in gammas.

3. At the same time the magnetic field lights in the FIELD/TIME display, another number appears in the STATION/DAY display, for example:

0	STATION/DAY

   This is the station number. Both displays will stay lit for about 5 seconds, then go out.

4. To store the reading in memory, depress STORE while the displays are still lit. If the displays go out before you depress STORE the reading will be lost and the ERROR message will come on. After you depress STORE the display will go out.

5. To recall the reading from memory, depress

RECALL 7

The FIELD/TIME display will light with the field reading and the STATION/DAY display will light with the station number that was stored with it.

In summary,	by depressing READ	you've taken a reading of the magnetic field
	by depressing STORE in memory	you've stored that reading
	by depressing RECALL from memory	you've recalled the reading

The next section provides instructions on every phase of operation. Each part of operation is presented in the order in which it would normally be done in actual use.

C. Actual Use

This section includes operational instructions. Notice that the operational procedures are divided into nine parts, and they are listed below in the order in which they appear in the manual.

Overview:

1. Clearing a Key Sequence
2. Setting the Clock
3. Using the Line Number Marker
4. Tuning the Magnetometer
5. Taking and Storing a Reading
6. Recalling from Memory
    a. Recalling from Memory - last reading
    b. Recalling from Memory - particular reading
    c. Recalling from Memory - second half of memory line
7. Erasing Data
    a. Erasing data - last reading
    b. Erasing data - last group
    c. Erasing data - entire memory.

8. Setting Auto Mode

   a. Displaying the last field reading taken

   b. Accessing real time

   c. Shutting off Auto Mode

9. Retrieving Data

Expanded Explanation:

1. Clearing a key stroke or key stroke sequence
   Depress

   | CLEAR |

   (A) When you depress CLEAR the displays will go blank and any key stroke(s) will be "erased."

2. Setting the Clock (Julian date/time)

	AUTO	TIME	SHIFT	
then	(day) +	(day) +	(day) +	
then	(hour) +	(hour) +	(min.) +	(min.) +
then	ENTER			

There are a number of features of the internal clock, and they are discussed in several places in this manual. It is especially important to set the clock properly when doing diurnal corrections. The survey maps and the base station mag clocks must be synchronized. A brief description of the key sequence involved in setting the clock includes:

- Check the clock to see if it needs setting.
- Select a time in the near future when you will start the G-856 clock.

- Shift into AUTO mode (the clock can only be set if AUTO is pressed before TIME).
- Depress TIME, SHIFT, and then numbers for the day, hour, and minutes.
- Wait for real time to match your preset time, and press ENTER to synchronize the G-856 clock.

Start by determining if the clock needs setting. Depress TIME. The time will light in the displays. Hour, minutes, and seconds will light in the FIELD/TIME display. The seconds will be running. Another number will light STATION/DAY display. Compare this indicated time to your watch, time standard, or your base station instrument and decide whether you need to set the clock. The display will go blank automatically in 5 seconds; to speed the process, depress CLEAR. If you decide that you need to set the clock, go through the following sequence.

- Depress AUTO
- Depress TIME

The displays will light with the current time setting. The STATION/DAY display will show the Julian Date. To change it, determine the time at which you will start the clock, and key in the numbers as follows.

- Depress SHIFT to access the numbers on the keys
  When you do this the lower display will show:

  _ _ _ STATION/DAY

- Depress:

(day) +	(day) +	(day) +

Numbers for the Julian day, for example, April 13 is day number 103. As you do this, the STATION/DAY display will fill with the new setting. If you don't wish to change the day of-the-year value, just re-enter the old number.

- Next, depress:

(hour) +	(hour) +	(min.) +	(min.) +

Numbers for the hours and minutes. As you do this, the FIELD/TIME display will fill with numbers.

- Clock Set At the instant the display matches your time standard depresseuter. When you do this the new Setting will be entered and the display will go blank.

You can check that the time is correct by depressing TIME. The displays will light with the newly set time. The seconds will be running.

Note that the old clock keeps running inside the G-856 until you press ENTER. If you make a mistake in the sequence, just press CLEAR and you will have the old time restored.

ENTER can also be used after the Julian Date is keyed in so you can change that number without resetting the clock. In other words, you are free to use the Julian Date as another variable like the Line Number but remember that in auto cycle this number increments every 24 hours; (see section III).

Notice that depressing SHIFT accesses the numbers that are on the bottom portion of the key. This is different than most other keyboards, where SHIFT will access what is on the top portion of the key.

3. Setting the Line Number (Survey Mode)

In surveying, you will want to use a special designation called the line number to help you in recording your position (see Chapter 2, Mobile Survey Operation, for further details). When in Survey Mode, this 3 digit number appears in the STATION/DAY display when TIME is depressed. (Note: When in AUTO Mode, the three digit number appearing when TIME is depressed is the Julian day of the year).

> Both the current line number setting and the Julian day are recorded for each reading taken, although both are not available for viewing on the displays. (If the reading is taken in survey mode, the line number is displayed when TIME is depressed; if the reading was taken in auto mode, the Julian day is displayed when TIME is depressed). The data file of the G-856, however, provides all the information: the line number, the time and Julian day, the field reading, and the station number. (See Chapter 3 for a more thorough discussion).

Be sure you are not in auto mode when setting the line number.

To change the line number:

- Depress TIME

The FIELD/TIME display will light with the real time and the STATION/DAY display will light with the current line number.

- Depress SHIFT to access the numbers on the keys. When you do this the STATION/DAY display will show

- - -	STATION/DAY

Now key in the new line number. As you do this, the display will fill.

- Depress [ENTER]

The display will blank and the new line number will be stored with the next field readings. To verify proper entry, press [TIME].

4. Tuning the Magnetometer:

The magnetometer needs to be tuned for the same reason that a radio requires tuning, to achieve the best signal strength. The tuning procedure is a-matter of matching the circuits response to the intensity of the actual field value.

Usually, fairly accurate readings can be obtained by merely entering a number within 3,000nt of the actual field reading. Each time a new survey is started precise tuning should be adequate to obtain the maximum signal.

If you do not know the approximate magnetic field for your area, locate your position on the world magnetic map in the front of this manual. The map will provide you with the approximate field for your location.

The magnetometer may be tuned to 3-digit resolution (e.g. 57.4 kilo-gammas) but internally it selects from 256 possible steps. This allows you to tune the magnetometer very precisely which will result in less scatter and more accurate readings. Approximate tuning will be adequate for most surveys.

Remember--the following sequence only works if the magnetometer is functioning properly. You will need to be outdoors, away from power lines and large metal objects.

To tune:

- Use the world magnetic map to determine the normal field for the area being surveyed.
- Tune the magnetometer to three digit accuracy, (540 is 54,000 gammas).
- Take a reading.
- Retune to match the reading obtained.

You will depress:

[TUNE] [SHIFT]
(1)

[+] [+]
(2)

[ENTER]
(3)

READ
(4)

TUNE
(5)

a. Depress TUNE TUNE

- When TUNE is depressed, a number will appear in the display.

51000.6	FIELD/TIME
7 5	STATION/DAY

- This is the signal strength, a number ranging from 0.0 to 9.9 which describes the strength of the signal received on the previous measurement.

After the signal strength goes out, the current tuning value will appear in the displays.

tunE	FIELD/TIME
51 0	STATION/DAY

This number should be read as 51,000 gammas. The tuning range is between 20,000 and 90,000 gammas.

b. Next, decide if the present tuning value is valid. If it needs to be changed you will need to enter in numbers for whatever the new tuning value should be.

- Depress SHIFT to access the numbers or the keys.

- Depress numbers for the new tuning value, for example:

5	6

(56,000 gammas). Zeros will be entered for any space on the display not given a number.

- Depress ENTER When ENTER is depressed the new tuning value will be activated. The displays will go blank. You will want to check the tuning by taking a reading.

- Depress READ

- You will want to check the signal strength achieved at the new tuning value. Depress TUNE

The displays will again light with a signal intensity number, for example,

51 6	FIELD/TIME
8.5	STATION/DAY

- If this is satisfactory signal strength, you will begin your survey. If you need to increase the signal strength, you will want to be more precise in the tuning value entered. You might want to take a reading and enter in the first three digits of that reading for the tuning value. Some trial and error is usually required to receive the maximum signal strength possible. In general, maximum signal strength is received when the tuning value matches that of the field. Signal strength length levels of --- to --- are typical and provide good constant results.

5. Taking and Storing a Reading

This part of operation was explained in the section called OPERATION PROCEDURE. Briefly, the keys depressed to take and store a reading are

READ STORE

The next operational procedure, Recalling from Memory, expands on the use of the RECALL key to access the memory.

6. Recalling from Memory

A good way to understand the memory is to think of the data as being in a "stack" of lines, each line being made up of 2 parts. One part is the FIELD READING and STATION NUMBER, the other part is the TIME and LINE NUMBER or DAY. The line number will appear if the reading was taken in survey mode. You will see the Julian Day if the reading had been taken in AUTO mode.

The memory is accessed by depressing RECALL. When you do this the first half of the last ("top") line in the memory stack will light in the display. See Figure 1

Figure 1 Memory Stack

If you depress RECALL, the last line stored in memory lights in the display.

This reading lights in display	(field)	(station)	(time)	(line no.)
	67856.8	009	12.32.55	10
	68645.5	008	12.32.30	10
	68857.4	007	12.32.00	10
	68682.9	006	12.32.54	10
	68432.8	005	12.32.20	10
	68845.7	004	12.31.59	10
	68723.8	003	12.31.37	10
	68245.6	002	12.31.02	10
	68290.0	001	12.30.45	10

If you depress RECALL again, the memory decrements again, and the next reading will be displayed. See Figure 2.

Figure 2

Decrementing the Memory Stack

This reading lights in display	(field)	(station no.)	(time)	(line .no.)
	67856.8	009	12.32.55	10
→	68645.5	008	12.32.30	10
	68857.4	007	12.32.00	10
	68682.9	006	12.32.54	10
	68432.8	005	12.32.20	10
	68845.7	004	12.31.59	10
	68723.8	003	12.31.37	10
	68245.6	002	12.31.02	10
	68290.0	001	12.30.45	10

Depressing RECALL will continue to decrement the memory and each reading down the line will be displayed. Depressing ENTER will increment the memory.

In a large stack of data, it is not necessary to keep depressing RECALL or ENTER until the desired reading is found. In cases where you wish to look at the 5th reading or the 65th reading, the memory will respond if you depress:

[RECALL] [SHIFT]
(1)

[(station)+] [(station)+] [(station)+]
(2)

[ENTER]
(3)

Examples:

Depress

RECALL		SHIFT

to access the memory and the numbers on the keys.

Depress the numbers of the station number you wish to look at, for example 3, 5, 6. As you depress these numbers, the display will fill.

Depress

ENTER

The STATION/DAY display will read 356 and the FIELD/TIME display will light with the field reading taken at that station.

Accessing the other half of the memory line (the time and line number) requires depressing the TIME key while the first half of the memory line is being displayed. For instance, let's say you recall station number 555 from memory. (Depress RECALL, SHIFT, 5, 5, 5, ENTER). The field reading along with the number 555 will light in the displays. See Figure 3.

Figure 3

Display of First Half of Memory Line

The first half of this reading lights in display → 68882.9

(field)	(station no.)	(time)	(line no.)
68856.8	558	13.32.55	10
68845.5	557	13.32.30	10
68857.4	556	13.32.00	10
68882.9	555	13.32.54	10
68832.8	554	13.32.20	10
68845.7	553	13.31.59	10
68823.8	552	13.31.37	10
68845.6	551	13.31.02	10
68890.0	550	13.30.45	10

While the reading and station number are displayed, depress TIME, and the second half of the line, which consists of the time the reading was taken and the line number marker (or Julian Day, if the reading was taken in AUTO mode) will be displayed. See Figure 4.

Figure 4

Display of Second Half of Memory Line

(field)	(station no.)	(time)	(line no.)	
67856.8	009	13.32.55	10	
68645.5	008	13.32.30	10	
68857.4	007	13.32.00	10	
68682.9	006	13.32.54	10	
68432.8	005	13.32.20	10	
68845.7	004	13.31.59	10	Depressing
68723.8	003	13.31.37	10	TIME displays
68245.6	002	13.31.02	10	this half of
68290.0	001	13.30.45	10	the line.

Remember that when viewing the second half of the memory line, the time that's displayed is an historical record--the time at which the reading was taken. This is different than real time which is displayed with the seconds running.

While you are in the second half of the memory line, you can decrement or increment also, just by depressing [RECALL] or [ENTER]. To get the first half of the memory line back, depress [FIELD].

With the concept of the memory stack in mind, the following directions on using the RECALL key will be clear.

a. Recalling from Memory--last reading

Depress

[ENTER]
(1)

The last magnetic field reading in memory will be displayed in the FIELD/TIME display, and its station number will appear in the STATION/DAY display.

b. Recalling from Memory--particular reading in mid-stack

Depress [RECALL] [SHIFT]

[(station)+] [(station)+] [(station)+]

[ENTER]

To access the memory and the numbers on the keys.
Depress numbers for the station number you wish to view, for example, 1, 2, 3.

Example:

Depress ENTER

The STATION/DAY display will light with 123 and the FIELD/TIME display will light with the magnetic field reading taken at that station. (If you need to recall a four digit station number, simply enter in 4 digits. The STATION/DAY display will flash with the first digit, blank, then flash with the next three least significant digits.)

NOTE: You cannot reach a memory location without data in it. If you don't have 123 readings stored, the stack will go to the highest valid number. You can also find the highest number by pushing READ.

c. Recalling from Memory--second half of memory line

Part of recalling data from memory has been performed by depressing RECALL, the station number and ENTER. However, that key sequence only gets you the first half of the memory line. To see the time at which that reading was taken, and also the other 3 digit number stored with it, depress TIME

TIME must be depressed while the field reading is still being displayed. The FIELD/TIME display will then light with the hour, minutes, and seconds at which the reading was taken and the STATION/DAY display will light with the line number marker (or Julian Day if the reading had been taken in auto mode. See Setting the Clock and Setting the Line Number (Survey Mode).

Any time you depress TIME when no field reading is being displayed, the real time will be displayed with the seconds running. This is how you can be sure of keeping historical time and real time separate. Real time seconds run. Historical time seconds do not.

Once you get the second half of the memory line, that half of the data will be displayed. You can increment and decrement in the second half just as you would in the first half, by depressing ENTER and RECALL respectively.

When you want to return to the first half of the memory line:
Depress FIELD

The FIELD/TIME display will revert back with the field reading, and the STATION/DAY display will show the station number. The instrument will also return to the first half or the memory line if you take a reading.

7. Erasing Data

The G-856 will allow you to erase the last reading, a last group of readings, for example from 356 on, or the entire memory.

a. Erasing Data - last reading
Procedure

READ	RECALL	ERASE	ERASE

Depress **READ**

The READ key will move the memory stack to the position of the last reading taken.

Depress **RECALL**

The last reading taken will appear in the displays.
While the displays are still lit with that reading:

Depress **ERASE** **twice**

The displays will go blank and the last reading will be erased from memory. ERASE must be depressed twice in order for the reading to be erased. This is a data protection feature. If ERASE is accidentally pressed, depress CLEAR, or any other key, to abort the erase operation.

b. Erasing Data - last group

To erase the last group of readings, first determine at what station number you wish to begin the erasure. All data will be erased from that station number to the last reading stored in memory

RECALL	SHIFT		
(station)+	(station)+	(station)+	(Enter Station Numbers)
ENTER	ERASE	ERASE	

Depress **RECALL** to access the memory and depress

SHIFT to access the numbers on the keys.

Depress numbers for the station number at which you wish to begin the erasure, for example 7,4,8.

Depress **ENTER** The displays will light with the station number 748 and the field reading taken at that station. While the displays are still lit with that reading, Depress ERASE ERASE The displays will go blank and all data from 748 to the last reading will be erased from memory. ERASE must be depressed twice for the data to be erased.

c. Erasing Data - entire memory

To completely clear the memory of information, you need to enter in the first station number (0) and depress

ERASE twice

Depress:

RECALL (1)	SHIFT (2)
0 (3)	
ENTER (4)	
ERASE (5)	ERASE (6)

Depress RECALL to access the memory and depress SHIFT to access the numbers on the keys.

Depress 0, which is the first station number in memory.

Depress ENTER The displays will light with 0 and the field reading taken at that station. While the displays are still lit,

Depress ERASE ERASE The display will go blank and the entire memory will be cleared of information.

8. Setting Auto Mode

Auto Mode allows the magnetometer to take readings automatically at a specified interval. When the magnetometer is "cycling" automatically, it is usually stationary and is then called a base station. It's purpose is to record readings of the earth's diurnal field that can then be compared with the survey magnetometer's readings. In this way, a more accurate picture of the magnetic subsurface can be obtained.

The G-856 is able to store about 12,700 readings in the auto mode compared to the 5000 readings it stores in survey mode. The reason is that the time interval at which readings are stored is fixed, and so the specific time that each reading is taken can be automatically calculated when retrieving data. Since these items don't need to take up memory space, the memory for magnetic field data becomes larger in auto mode, (but notice that no information is lost). In auto mode, the Memory-Mag magnetometer can record as much as one reading every minute for over 40 hours.

In auto mode, when viewing the second half of the memory line, the three digit number displayed in the STATION/DAY display increments at 24:00 midnight. This number should be set to represent the Julian (numerical) Day of the year. (Refer to Figure 5).

You'll recall that this differs from how the magnetometer functions under regular survey conditions. In survey mode, the three digit number doesn't increment automatically because it is most often used as a line number marker.

Figure 5

Display Differences in Auto and Survey Mode

Memory Stack			
Field	Sta. #	Time	Day
56890	347	12.19.20	112
5679000	348	12.20.20	112

AUTO MODE

Memory Stack			
Field	Sta. #	Time	Line
56780	176	12.19.20	100
567980	117	12.20.00	200

SURVEY MODE

The following instructions assume that the clock has already been set (see Setting the Clock). Setting AUTO mode requires selecting the sample interval at which the magnetometer will take samples. The procedure is as follows:

Procedure:

Depress [AUTO] [SHIFT]

(1)

[(seconds)+] [(seconds)+] [(seconds)+]

(2)

[ENTER]

(3)

Example:

Depress [AUTO]

The displays will light with a number.

[AUTO] FIELD/TIME

[1 20] STATION/DAY

This is the current sample interval in seconds. If you like that setting, you can just depress ENTER [step (c)], and the magnetometer will begin taking readings every 120 seconds. If you need to change that sample interval, depress SHIFT to access the numbers or the keys. The displays will show spaces.

Next, depress numbers for the new sample interval, for example, 60 seconds. The display will fill with those numbers. Before 5 seconds lapse, Depress ENTER If ENTER is not depressed within 5 seconds the setting will clear. When you depress ENTER, the instrument will start taking and storing readings automatically.

There is a setting on the internal Option Switch that allows the displays to be turned off in Auto Mode to save battery power. See Using the Programming Switch in Chapter 4. If this switch is used, the displays will light with each sample for 5 minutes, then shut down. You can enable the displays again for 5 minutes by depressing any key.

a. To read the memory during AUTO mode, you depress RECALL and FIELD or TIME as desired. The Julian day will be displayed with TIME.

b. To access the real time.

Depress TIME

The FIELD/TIME display will light with the real time and the STATION/DAY display will light with the line number. If you press AUTO first, then TIME, the Julian day will come on. Look for the seconds to tick to verify correct time.

c. To shut off Auto Mode

Depress AUTO CLEAR

The displays will blank and Auto Mode will shut off.

When the cycle time is short, the above operations (8 a, b, c) will be slightly delayed because the instrument and displays will be busy taking readings. For instance, to shut off auto mode you will have to hold AUTO down for one complete cycle, then hold CLEAR down for one complete cycle.

As explained in the section Recalling from Memory, you may recall a 4 digit station number simply by depressing 4 digits. The STATION/DAY display will flash briefly with the most significant digit, followed by the three least significant digits. The FIELD/TIME display will flash with the magnetic field reading taken at that station.

NOTE:. There are 4 key sequences that will produce an ERROR message in auto mode. They are:

1. Depressing the OUTPUT key.
2. Depressing the READ key.
3. Depressing the STORE key.
4. Attempting to change the sample interval while the magnetometer is automatically cycling. You must shut down auto mode to change the sample interval.

9. Retrieving Data

Data can be retrieved both manually (See Chapter 3) and automatically.

To begin automatic retrieval of data, connect the G-856 to an auxiliary piece of equipment (computer, printer, magnetic tape recorder, or another magnetometer) using the optional RS-232 interconnect cable:

Depress | OUTPUT | | ENTER |

The information stored in memory, beginning with the first station number, will be automatically transmitted. The station number will flash so you can monitor progress. To interrupt (stop) the process, press CLEAR. The data will remain in the memory until you erase it.

You may begin automatic retrieval at any station number. The key sequence to begin transmitting data from station number 123 would be:

Depress | OUTPUT |

Depress | SHIFT |

Depress the desired numbers, for example | 1, 2, 3 |

Depress | ENTER |

The G-856 will begin transmitting data at the designated station number.

<u>Summary</u>

This chapter has presented the steps needed to operate the G-856. As a further aid, a short reference section summarizing this information is presented in the appendix. Chapter 2 discusses the features and performance of the G-856 in special survey situations. The chapter begins with instructions on connecting the sensor; proceeds with information sensor orientation, positioning, and repeatability; continues with a section on the magnetic environment, and ends by discussing some possible techniques that might be used in data collection.

Chapter 2

Field Operation

This chapter will discuss the features and performance of the Memory-Mag magnetometer in regard to actual survey use. Included here is information on sensor attachment and discussion of sensor orientation and positioning in relation to the repeatability of the instrument's readings. Discussed also are testing for magnetic noise and some particular features concerning the use of the magnetometer as both a base station and also a survey unit.

A. Sensor Attachment

Inside the sensor case are coils of wire submerged in a hydrocarbon fluid, in this case, Shell SOL-71 Mineral Spirits. The following section presents proper mounting procedures for the sensor.

1. Check for sensor fluid volume by shaking and listening for a "sloshing" sound. The fluid should sound like it's about 1 cm. from the top of the sensor. If you need to add fluid:

    A. Remove the blue cap plug on the sensor.

    B. Fill with fluid (see below) to within 1 cm. from the top.
    The following is Acceptable Fluids list that may be used in the G-856:

    Acceptable Fluids for Proton Magnetometers

    Preferred fluid: Shell SOL-71 (Shell Oil Co.)

    Acceptable Fluids:

    1. Charcoal Lighter Fluid (Kingsford, Wizard, etc.)
    2. n-Decane (chemical supply houses, oil refineries)
    3. ISOPAR-G (Exxon Oil Co.)
    4. Odorless Mineral Spirits (Naptha)
    5. Mineral Spirits (Naptha)
    6. Kerosene Lamp Oil
    7. Kerosene
    8. Mineral Oil (Medicinal grade)
    9. Diesel fuel
    10. Camp Stove Fuel
    11. White Gas
    12. Unleaded Gas

Items 11 through 12 have a very low flash point and should be used with extra caution. Although any petroleum product must be handled carefully.

There are several alcohols which will produce an acceptable signal, but will tend to absorb water. This will degrade the performance of the sensor over time. These alcohols should be replaced as soon as possible with a fluid from the above list. The preferred fluids are Shell SOL-71 and items 1 through 6.

Usable Alcohols:
1. Ethanol (grain alcohol) at least 190 proof.
2. Methanol (wood alcohol)
3. Denatured Alcohol (Ethanol made poisonous)

All of these fluids must be as clean as possible to ensure that no water or rust is contaminating them.

C. Replace plug.
Using Teflon Tape to prevent leakage

2. Attach the signal cable to the sensor.

3. Attach the sensor to the staff and assemble the sections.

B. Sensor Orientation

The sensor is marked with an arrow and the letter "N". During operation this arrow should be roughly pointed either north or south. Aligning the sensor this way will place the coil axis perpendicular to the Earth's field and produce an optimum signal. Aligning the arrow east or west will cause reduced signal amplitude.

As surveys approach low magnetic latitudes where the field dip is less than 40° and the field value generally below 40,000 gammas, (such as near the magnetic equator where the field is close to horizontal) the sensor should be mounted horizontally (saddlemount) on the staff. In this manner the sensor coils will be properly oriented for maximum signal. Because less signal produced at the low field strength areas, it is more important that the tuning is peaked for maximum. See page 3 for hints on increasing signal to noise ratio.

C. **Sensor Position/Repeatibilty**

Sensor position, in this case meaning the exact and consistent placing of the sensor, is very important to the repeatability of the system. Repeat ability means getting the same count for several readings taken consecutively when the sensor is not moved. This relationship between sensor position and repeatability becomes more and more critical as portable magnetometers increase in sensitivity. The following instances are of particular concern: areas of high gradients, areas where the diurnal field is changing rapidly, and areas where magnetic dust is present. It's because of these instances that a 0.1 gamma magnetometer may not repeat as consistently as a 1 gamma unit. To illustrate, consider the following comparisons:

HIGH GRADIENTS: In an area of l sq. meter where the magnetic field varies by several tenths of a gamma every 15 centimeters, a 1 gamma magnetometer will not be affected by moving the sensor slightly, or even moving it as much as 30 or 40 cm.

However, given those same conditions, the repeatability of a 0.1 gamma magnetometer will be affected, and possibly quite noticeably by moving the sensor as little as a few centimeters.

RAPID DIURNAL CHANGES: Consider also that even if the sensor is held perfectly still, a 0.1 gamma magnetometer will pick up subtle changes in the diurnal field that a 1 gamma magnetometer would never detect. This is of particular concern during high sunspot activity.

MAGNETIC DUST: Added to this is the possibility that the sensor itself may be magnetically contaminated due to an inclusion or surface adherence. This may affect data greatly if the sensor is rotated or the orientation continually changed.

OPERATOR CONTAMINATION: A key, ring, knife, or other magnetic object carried by the survey operator can also become a source of errors in the magnetic data. In addition, steel-clad batteries, if installed in the instrument, will almost certainly cause a field error at the sensor.

As a note to the above, there may be other complications to repeatability. One is electrical noise in the system that may produce variations on the order of 0.1 gamma. Another possibility is the statistically random count of proton precession by the system. Again, a comparison between a 1.0 gamma magnetometer and a 0.1 gamma magnetometer is needed to make the point.

To explain further, the G-856 operates by counting the frequency of spinning protons in the sensor (for more information see Applications Manual for Portable Magnetometers). The length of, or the amount of time involved in this count, affects repeatability in a very subtle way. For instance, in a 1 gamma magnetometer, given a normal 3 second cycle time, a certain number of protons will be available for the count. Take as an example the field value of 53795.2. The 1 gamma magnetometer will round that count to 53795. The next count is 53795.3. Again the magnetometer rounds to 53795. In a 0.1 gamma magnetometer, however, that count will be more accurate; the magnetometer reports the counts as 53795.2 and 53795.3 respectively. Of course, this accuracy lessens the repeatability.

D. Truncating Digits on the Display

In areas of very high gradients, often times the environment does not permit the magnetometer to capture an accurate count. This happens because the sensor signal collapses, or dies, before the count time has ended, creating an inaccurate picture of the field. The operator will recognize the symptoms of high gradients by noting truncated digits on the display and a series of 5 quick beeps. When the signal has collapsed too soon, the magnetometer will drop the least significant digit and leave an incomplete reading on the display.

Depending on the resolution you need, this is most likely not a problem. If the cause is high gradients, there is no need for 0.1 gamma resolution. A similar effect may be observed in very low fields. You can usually improve the signal strength by shortening the count time and/or lengthening the polarization time. See Using the Programming Switch in Chapter 4.

E. Magnetic Environment

In surveying, it's important that magnetic field readings be as true as possible and not be affected by articles of clothing and personal accessories. Jewelry, keys, watches, belt buckles, pocket knives, zippers, etc. can affect the total magnetic field reading. Objects suspected to be magnetic may be checked in the following manner:

1. Mount the sensor on the staff, place the suspected article far away from the sensor, and take several readings. Each reading should repeat to ±1 gamma. (For details see Sensor Position/Repeatability on-the previous page.)

2. Place the suspected article fairly close to the sensor, and again note the readings.

3. Remove the article and again take several readings to check for a diurnal shift in the earth's field. If a shift is present, repeat the test.

4. If no diurnal shift is present, you can assume that the article is magnetic if the first group and the second group of readings varied by more than 1 gamma.

If the article is highly magnetic, or if the sensor is inside or near a building or vehicle, the proton precession signal will be lost, giving completely erratic readings (and 5 quick beeps).

The magnetometer can not reliably be operated in areas that are known sources of radio frequency energy, where power line noise (transformers) is present, in buildings, or near highly magnetic objects. The sensor should always be placed on the staff above the ground, or in the "backpack". The sensor will NOT operate properly when placed directly on the ground.

F. **Magnetic Surveys**

1. SURVEY OPERATION

During survey operation and after the instrument is tuned to the local field intensity (refer to Chapter 1), the operator need only depress the READ key to observe the reading, and if the reading is acceptable, the STORE key. If the reading is in question, for example a sudden shift of several hundred gammas, another reading should be taken.

2. DATA PROCESSING

For downloading and processing of G856 data see the MagMap 2000 manual. Also available for sonce body modeling is our analysis program MagPick, both available from our website. www.geometrics.com.

Note: MagMap 2000 program will automatically do diurnal correction if both survey and base titles are downloaded into the program. It is important that the clocks and days be synchronized prior to data recording.

Chapter 3

Data Retrieval

This chapter explains manual transcription of data for use if no PC computer is available. It also explains the process of using other instruments to retrieve data collected by the G-856 Memory-Mag magnetometer, presenting the possibilities that can be achieved. Some computer knowledge is helpful in performing automatic retrieval of data. Nevertheless, even a novice will be able to print the magnetic field reading, the time each reading was taken, the line number, and the station number. We recommend that you use MagMap2000 as your primary download and processing software program.

Before beginning retrieval of data, be sure to check that the batteries are holding a sufficient charge well above 7.5 volts. Failure to do this could result in incorrect or incomplete data. A simple test of the battery voltage is to press READ when the sensor is not attached. A voltage of 9.0 volts or greater should be noted before beginning retrieval.

A. **Manual Transcription**

To manually retrieve data, find the first reading In the survey (often 000) from your field notes or by iteration (see Recalling from Memory). After the first reading is found and data written down, depress ENTER to increment the magnetometer as many times as needed to see and hand record all the data.

If you are retrieving data from a base station, you will be looking for a specific time rather than a station number. Start with a guess and iterate until you find the precise time.

Assume that you have completed a field survey which took four hours and that at the same time had a base station operating from one hour before to 20 minutes after the survey, taking readings at I0 second intervals. You have made a list of the field data including the time of each reading, and the first reading was recorded at 13:04:27. When the base station READ button is pushed, the STATION/DAY display flashes 1, followed by 919, so you know that your first survey reading is about one hour after the start of your five hour and twenty minute record containing 1919 readings.

Pick reading 300 as a first guess and press: RECALL, SHIFT, 3, 0, 0, ENTER, TIME. The display will light with the Julian Date and a time, for example 12:50:02. This first guess was too early, so try 400 next: SHIFT, 4, 0, 0 ENTER. Notice that you do not need to press TIME again once you. are in the Time display mode. This time the display reads 13:07:42, a little too late. When you repeat the guess at 390, you get 13:05:02, a fairly close number. Now push RECALL over and over, getting a sequence of numbers: 13.04.52, 13.04.42, 13.04.32, 13.04.22. The last number is close enough. If your last guess had been just a little early, you could have advanced by pushing ENTER to increment the stack pointer.

Once you have the desired time In the window, push FIELD, which returns the magnetic field reading to the display. That becomes your baseline for diurnal correction of the survey data. Note that an automated diurnal correction process is included in MagMap2000 program described in separate documentation.

B. <u>Use with a Computer</u>

The G-856AX was designed to be used with a computer for fast and accurate download and analysis of the data. Geometrics has spent man-years developing and upgrading our magnetometer interface software. Currently we are supplying MagMap2000 for use on IBM PC compatible computers running Windows 98, 98SE, NT, ME, 2000 and XP operating systems. We will of course keep the software up to date on whatever current operating system is being used.

MagMap offers a huge advantage when performing routine download, profiling, contouring and diurnal correction of magnetometer using a basestation. The software has a special section designed especially for 856 interface and data handling. We strongly recommend that the MagMap software be used for the data download and initial processing. The latest version can be downloaded free of charge from our website www.geometrics.com. The complete operating manual is included in the software as a Adobe PDF document under Help. Download the free Adobe Acrobat Reader from www.adobe.com.

While we recommend that you spend the time to review the MagMap documentation, here are some of the things you can do with the software:

1. Download the 856 memory using a RS-232 interface at 9600 baud. This takes about 10 minutes for a full memory land survey (5700 readings) or about 20 minutes for a full memory base station survey (12,500 readings). Downloads can be for single sensor, dual sensor (gradiometer) or base station configurations.

2. Define the Grid and interpolate all data. MagMap allows the user to define the spacing between discrete readings and between survey lines. Then the program assigns a position to each reading creating a uniform grid. Positions are editable in individual or line mode. Later this ASCII (Text) file of the position, mag reading and time can be exported to other popular analysis programs such as our free MagPick program, Geosoft or Surfer gridding and contouring analysis packages.

3. Search the data for spikes or erroneous readings and remove them.

4. Flag anomalies in the profile data that are associated with targets of interest (archeological, environmental, utility, ordnance, geological, etc.) and plot the flags on the position map showing where they are located on the survey grid.

5. Create maps of the data in 2-D or 3-D mode with multiple color or shaded relief contours. The Flags discussed in item 4 above are also reproduced on the 2-D and 3-D maps allowing the user to define the large position.

6. Export the data for additional analysis. Please review our stellar MagPick Processing Software package on our web site. Note that this allows the user to estimate the target position, depth and size as well as make impressive contour maps. Use of this software will take some effort on the part of the computer operator, but the results are well worth the effort.

Please contact Customer Service (support@mail.geometrics.com) or Sales (sales@mail.geometrics.com) for additional support in using the 856 with computers.

Chapter 4

Supplemental Information

A. **Instrument Storage**

After use: Disconnect the sensor cable from the magnetometer.

Store all the components in the shipping container to prevent magnetic contamination.

If the magnetometer system will be stored foe a long time, remove the batteries to prevent electrolytic leakage or corrosion of the contacts. DO NOT REMOVE THE LITHIUM BATTERY which is soldered into the circuit board.

The recommended storage temperature for maximum battery life is 40°F (4°C). If you wish to store batteries for a long time, do so in your refrigerator. In addition, wrapping the cells in a plastic bag will prevent moisture formation while in the cold. These batteries should be allowed to warm up in the bag before being used.

B. **Batteries**

There are three kinds of batteries in the G-856 Memory-Mag™ magnetometer. Basic operation is powered by 9 D-cell batteries or by optional rechargeable gel cell battery pack. The clock and memory are powered by a lithium battery installed on the digital circuit board when the main batteries are disconnected or removed.

C. **D-cell Battery Types**

When the magnetometer is used as a base station, alkaline D-cell batteries will work satisfactorily. Figure 6 compares the expected number of readings possible for different battery types. Note that an optional external sensor power cable is available for base station use that allows the user to connect a 12v car battery to power the system. A typical fully charged car battery will last many days powering the 856 in base mode.

When the sensor is mounted on the staff, only cardboard or plastic jacket batteries should be used. If steel jacketed batteries (carbon zinc or alkaline) are used in the console during survey operation a directional dependent shift of several gammas will occur and will bias the measurement.

The optional internal gel cell battery pack is non-magnetic.

Figure 6

Number of Readings per Battery Type

Battery Type	Brand Name	Readings at 25°C	Readings at 0°C	Jacket type
Alkaline	Burgess, Eveready Duracell	6,000	4,000	Steel
Standard Carbon-Zinc (flashlight)	Burgess, Eveready Ray-O-Vac	1,500	700	Cardboard
Premium Carbon-Zinc	Eveready #1250*	3,000	1,700	Cardboard
Internal Gel Cell	Power Sonic*	Full Memory 12000	Full Memory 12000	Plastic

Figure 6 is based upon one reading every 30 seconds, using the 3 second cycle time setting (see Switch Options following). Faster sampling rates will yield fewer readings, especially at lower temperatures. Photoflash and "Energizers" are not designed for this type of application, but may be used until proper batteries are available. It should be noted that battery capacity decreases rapidly below 0°C to only a few hundred readings at -20°C. These battery types will recover, however, when warmed above 0°C. (see D-cell Battery Low Temperature Operation.)

D. D-cell Battery Voltage Indicator

After READ is depressed and before a reading of the magnetic field comes up on the FIELD/TIME display, a number indicating battery voltage appears. The indicator will display BATT and some number up to 19.9. This number is the actual battery voltage. Because the measurement of this voltage occurs during the polarize cycle of the magnetometer, the battery voltage indicator reports the amount of charge left in the batteries when they are under load.

It is possible that you may want to use an auxiliary power source with the G-856, which is why the indicator will read up to 19.9. When using just the internal D-cell batteries, however, the maximum voltage will read around 13.5 volts. When the indicator reads 8.2 volts the magnetometer will stop polarizing, and the batteries should be replaced. The "Low Batt" message will be displayed.

If you continue to use batteries that have discharged below 8.2 volts, the magnetometer may not respond to keyboard commands. Also, complete and accurate data cannot be ensured of you begin retrieving data when the batteries are not holding a sufficient charge. See Chapter 3, Data Retrieval for details.

*Available from Geometrics

E. **Low Temperature Operation**

At temperatures below 0°, battery life decreases rapidly. At -20°C, for example, operation may be limited to only 100 readings per set of batteries. At these lower temperatures, an optional Battery Belt (P/N 16069-01) or rechargeable gel cell battery pack (p/n) should be used, or the console may be held close to the operator's person, under warm clothing.

F. **D-cell Battery Replacement**

1. Unsnap and remove instrument cover.
2. Replace batteries matching the polarity markings on the battery holders.
3. Replace instrument cover. Be sure the instrument is seated all the way down in the case before trying to snap on the clops. Do not use the clips to force the unit into the case. Forcing them could cause breakage.

G. **Lithium or Keep Alive Battery**

In addition to the 9 D-cell batteries used to power the magnetometer in normal operation, there is an AA-size lithium battery, called the "keep alive" battery, used to power the clock and keep data in memory should the D-cells fail or be removed. The lithium cell should be changed about every 6-10 years. It is soldered into and underneath the top circuit board and should be replaced in the same manner. Be sure all data is removed from memory and recorded before the lithium battery is unsoldered from the circuit board.

H. **Lithium or Keep Alive Battery Replacement**

1. Unclip the cover and slide it off the circuit boards.
2. Remove the four screws holding the circuit boards together. As you separate the boards, unplug the cables noting their positioning as you do so. Lay the top circuit board down so the battery can be easily removed.
3. Unsolder the battery wires and wipe any debris from the battery area. Clear the plate through holes.
4. Check the polarity, then thread the lead wires on the new battery through the holes in the board.
5. Measure the current drain form the battery if possible. Drain should not exceed 50 micro amps.

   WARNING: Shorting the lithium battery will result in blowing an internal battery fuse and could result in over heating and possible explosion. Be sure the battery lead wires do not meet.

6. Turn the board over and solder the lead wires to the pads. Trim off any extra wire. Connection is made with wires running through the center of the board.
7. Replace the circuit boards, cables, screws and cover.

The clock will have to be reset after the battery is in place.

I. Maintenance and Troubleshooting

POSSIBLE SURVEY DIFFICULTIES

Survey Difficulty	Probable Cause	Corrective Action
Low Signal Amplitude (Display indicates less than 4 volts)	1. Magnetometer out of tune.	1. Retune magnetometer.
	2. Very high gradients.	2. Move out of the area or try switching to a short count.
	3. Broken sensor cable.	3. Replace or fix cable.
	4. Loss of sensor fluid.	4. Fill sensor with Shell SOL-71 to about 1/2 cm from the top.
	5. Sensor coil axis parallel to field.	5. Align sensor North-.South or in the saddlemount position.
Field display shows truncated digits (poor signal to noise ratio) and 5 beeps heard when reading taken	1. 50-60 Hz interference.	1. Move away from interference.
	2. Microphonics.	2. Avoid vibration mechanical shock to sensor while surveying.
	3. Broken sensor cable.	3. Replace or fix cable.
	4. High gradients.	4. See Erratic Readout.
	5. Generally weak signal.	5. Lengthen polarize time.
Erratic Readout	1. Magnetic storm or micropulsations.	1. Try later, especially at night.
	2. High geomagnetic gradient.	2. Hold sensor perfectly still. Try shortened count.
	3. Magnetic objects on operator.	3. Remove iron objects from pockets, belt, etc.
	4. Magnetic dirt on sensor.	4. Scrub or scrape magnetic particles off sensor.
	5. Review causes under "field display shows truncated digits.	
	6. Low battery voltage.	6. Replace batteries.
Displays do not light	1. Poor battery contact.	1. Check for loose batteries. Bend out contacts and clean.
	2. Low battery voltage	2. Remove batteries, then repress reset switch (SW2).
	3. Internal memory error.	3. Replace batteries.
No reading on STATION/DAY display	1. Interboard cable not connected.	1. Check cable for proper connection.

Low Battery Voltage Indication	1. Low voltage.	1. Replace batteries.
Display reads "ERROR".	1. STORE depressed when no reading lit on the display.	1. Take new reading, depress STORE before displays go out.
	2. FIELD depressed when depressing TIME did not precede it.	2. FIELD reading already displayed. The FIELD key is used to return to the first half of memory line. See Chapter 1, "Recalling from Memory".
	3. Incorrect or invalid key or key sequence depressed.	3. Consult Chapter 1. Depress key sequence again.
Display reads "data Err"	1. Internal memory error	1. Print out or transcribe all stored data, then depress ERASE ERASE.
	2. Power removed while instrument was in operating mode.	2. Dump stored data into recording device, then press ERASE ERASE.
	3. Power interrupt during AUTO cycle or OUTPUT.	3. Remove batteries. Press the INTERNAL RESET button on CPU board 16635-01. Install batteries. Set clock.
	4. Lithium battery malfunction.	4. Measure lithium battery voltage. If voltage is less than 3.2V, replace. (See page 30.)
	5. Control board.	5. Return board (P/N 16621).
Display reads FULL	1. Memory capacity is full of data.	1. Transcribe and erase some data to create memory space.
Console will not tune	1. Poor signal-to-noise ratio. See display reads truncated digits.	
	2. Low battery voltage.	2. Replace batteries.
Err message when tuning	1. Disable Autotune function.	1. See page 49 on. Autotune.
Partial numeric Display	1. Control board malfunctioning.	1. Return board (P/N 16621).

J. The RS-232 Interface

1. WHAT IS RS-232C?

In 1963, the Electronic Industry Association (EIA) established a standard to specify levels and protocol for interfacing data-terminal and data-communications equipment that use serial binary interchange. The latest revision to this standard has been in effect since 1969 and is referred to as RS-232C. While RS-232C specifies a very complex group of date lines and signal levels, most devices equipped with interfaces called "RS-232C" in fact offer a subset of the standard as their interface method. The G-856 is one such device. The RS-232C cable for the G-856 is provided with a 9-pin female D-connector.

2. CONNECTOR PIN ASSIGNMENT

Only 3 of 22 standard RS-232C data transmission lines are used in the G-856. The Geometrics standard RS-232C interface cable, Part Number 16492-01, is wired to connect directly to a PC 9-pin serial port.

The following figure lists the functions assigned to each pin of the RS-232 cable from the G-856.

Figure 7

9-pin connector RS-232	G-856 Front Panel	Function Description
2	T	Transmit Data - from the G-856
5	D	Signal Ground - Zero reference for interface
7	G	Clear To Send - When low, inhibits G-856 output. Leave open if not used.

3. VOLTAGE LEVELS

The RS-232C standard specifies voltage levels for the various data and protocol lines of the interface as ±12V nominal, with voltages from 5V to 25V being acceptable. A logical "1" (mark, off or false state) is indicated when the voltage at the interface point is more negative than -3V; a logical "0" (space, on or true state) is indicated when the voltage is more positive than +3V. Many "RS-232" devices, including the G-856, use 0 and +5 volts for these two logic levels ("TTL levels") instead of ±12V. Most devices designed to work with ±12V will operate correctly with "TTL levels" but there are exceptions. Many large mainframe computers and some minicomputers require data over long cables. If your external equipment requires full ±12V RS-232 levels, you will need to construct or purchase a TTL-to-bipolar interface driver. A schematic of such an interface driver appears in Appendix B.

Figure 8

Wiring Diagram - Front Panel Connector

Pin	Function	Remarks
A	Sensor	
B	Sensor	
C	Sensor Shield	
D	Ground	Power and Control Ground
E	No Connection	
F	Data Accepted	Input from External Device
G	Clear to Send	
H	Battery Positive	Connected to Internal Battery
J	Data 0	
K	Data 1	Note: Serial BCD is no longer used Character Serial BCD Out
L	Data 2	
M	Data 3	
N	Data Valid	
P	End of Data	
R	Instrument Power	External Power In. Otherwise Jumper to H
S	Synchronization	External Read/Store Command
T	Transmit Data	Part of RS-232
U	Receive Data	

WARNING. Clear all operating functions before removing external power or internal batteries. Failure to clear functions may produce a DATA ERROR. Before clearing the error it is imperative that stored data be dumped into a recording device to prevent complete loss of data stored in memory

4. OUTPUT FORMAT

The G-856 data format on RS-232 and BCD outputs is as follows:

a. Each transmitted character is in ASCII code and consists of:

1 start bit (always logic "1")
7 data bits (ASCII encoded)
1 parity bit (always logic "0")
2 stop bits (always logic "0")

b. Each line of data transmitted by the G-856 is as described on Page 33 and consists of 29 ASCII characters:

	# of Characters
Space or asterisk (*)	1
Line number	3
Space	1
Julian day	3
Space	1
Time	6
Space	1
Station number	4
Space	1
Field	6
Carriage return, line feed	2

c. After all data has been transferred by the G-856, a final character (ASCII EOT) is transmitted.

d. Transmission of data is initiated as described in the G-856 manual, page 33.

a. Press Output; Display: Out
b. Optional: Press Shift, NNN; to begin output from station number NNN
c. Press Enter; display should begin flashing with number in lower window incrementing as each station's data is transmitted.

Be sure that the baud rates of the magnetometer and device being transmitted to match and that G-856 Txd line is connected to computer Rxd line.

5. EXTERNAL POWER

The G856 may be run from external power if desired. Usually you will want to do this because the internal batteries are not sufficient for some specific applications: when surveying in extremely cold weather, or when using the three-reading average (or long polarize) on a base station. The instrument may also be run on 18 volts instead of 13.5 volts to improve the signal to noise ratio.

For this application, connect the external 12v car battery positive to pin R, and the negative terminal to pin D (ground). The G-856 may also be operated from a DC power supply, but this sometimes introduces interference that noticeably reduces signal quality. It is a good idea to install a 1.5-2 ampere fuse in the power input line.

6. EXTERNAL CONTROL OF OPERATION

If pin S, Synchronization, is connected to pin D, ground, the instrument will take a reading and store it automatically. This feature was provided so that a external device could control operation of the magnetometer, and so that readings could be synchronized as desired. You can connect two G-856 magnetometers together so that the readings will be made simultaneously. In a small-area survey (most commonly in archaeological applications) a long cord can be run to the base station for more precise diurnal corrections. You may also wire two G-856 magnetometers together to make a portable gradiometer.

Possibly the most interesting application is in simplifying field operation. If you locate a push-button switch (non-magnetic) and tape it to your staff about shoulder height and wire it to SYNC, you can use the hand holding the staff to operate the magnetometer. You sacrifice the discretion of examining each datum before storing it, but you gain a lot in convenience. Note also that you can use the Auto operation as an alternative and acquire data in "walking" mode. Once you establish a good interval between readings, just walk and stop while the instrument takes its data, then walk to the next point.

Note: SYNC is an output as well as an input. If a G-856 starts a cycle, either because read was pressed or because of Auto operation, SYNC is pulled low and held low until the end of polarize time, then it is released. If SYNC is pulled low externally, the cycle is started. External SYNC may be momentary or held low. If momentary, Pol will shut off at the normal time. If held low Pol time will be extended until SYNC is released. In this manner, two G-856s, wired in parallel, will be synchronized. Either unit may provide the start command.

K. Using the Programming Switch

LOCATION AND PURPOSE

The G-856 has a small programming switch on the microprocessor circuit board. This switch is actually a set of eight individual switches in a small plastic assembly about 1 cm by 2-l/2 cm in size. Its purpose is to allow you to adjust the operation of the instrument to make it more noise insensitive, accurate, power efficient or suited to your specific application.

To locate the switch, remove the instrument from its case just as you do to replace batteries. Look near the right rear corner on the top circuit board. You will find a rectangular switch with eight small levers. Because of its size, you will need a small, pointed object like a pencil to change the switch settings. Notice that the eight levers will have their "on" position identified by the word ON or by a small dot (different types are available and. interchangeable). You will also find the number 1 through 8 next to each small lever, identifying the individual switches. Typically switching 1 through 5 are off, switches 6, 7, and 8 are on.

SWITCHES 1 THROUGH 4 (POLARIZE AND COUNT TIME)

The first four switches adjust the polarize time and affect the sensitivity, speed, and power consumption of the instrument. There are two operations in a proton precession magnetometer. First, a current is fed to a coil of wire immersed in the hydrocarbon fluid, causing the protons in the fluid to align (polarize cycle). Then, the current is removed and proton precessions are counted for a short period (count cycle). These operations take time, and there are tradeoffs to be made in the selection of the length of time involved in each.

In the case of the polarize cycle, the current should be left on long enough to produce a good signal, but not so long that battery power is wasted and not so long that the reading cycle becomes inconveniently long. The precession signal, on the other hand, decays rapidly, and the best readings are obtained by counting for most of the strong (early) part of the cycle. Selection of the best time is again a tradeoff, since the duration depends on the polarization power, and also on the field strength and the magnetic gradient (high gradients cause the signal to collapse more rapidly).

Setting Options Switches 1 through 4

Switch 1, when on, will extend the polarize time from under two seconds to almost three seconds. Using this switch will give you a stronger precession signal, but lengthen the total cycle time and therefore shorten battery life.

Switch 2, when on, will shorten the polarize cycle to less than one second regardless of switch 1's position. This will speed up the cycle time and increase battery life, but the result is a weaker precession signal which in turn can result in lower accuracy.

Switch 3, when on, will shorten the precession signal count time. This of course, will speed up the cycle slightly, but more importantly this setting will help you get good, valid data under conditions where the precession signal might decay very rapidly, in areas of high gradients and low field values. When the switch is on, however, the resolution of the magnetic field becomes .2 rather than .1 gammas. This is the first switch that should be adjusted if the instrument is giving erratic or noisy readings.

Switch 4, when on, will cause the instrument to automatically take three readings, and compute the average. This obviously is designed to give you the highest possible sensitivity, at some significant sacrifice of cycle time and power consumption.
(Note: This option is rarely used as the increase in sensitivity is usually not warranted by increase in survey time and battery consumption.)

Near the magnetic equator, the field is very weak and many proton magnetometers do not operate well, especially those optimized for higher latitudes. Often, the signal may be small and decays before the end of the count period. The solution is to extend the polarization time (switch 1) and shorten the count time (switch 3) so that counting is finished before the signal goes away. You may find that switch 3 is sufficient for good data, or you may need both switches. <u>Remember that you may also need to rotate the sensor into the saddlemount position using the optional mounting bracket</u>.

In high gradients, the problem is similar to the situation at the magnetic equator in that the signal collapses before the end of the count. You will know you are in an area of high gradients when the display truncates, or drops the least significant digit and you hear 5 quick beeps. The solution is the same as that for the equator, switch 1 and switch 3 are used.

Using switch 2 and switch 3 gives a much faster cycle time, longer battery life, and less sensitivity. You would use this combination when accuracy is not important, but speed and battery life are important.

Remember that you can also improve the signal by operating the G-856 at a higher voltage. External power connections as well as other inputs are accessed through the front panel connector. The instrument will operate on 18 volts, with a corresponding increase in polarization power. You can also operate with longer cables in this manner. Please note that the G-856 should give satisfactory performance with its normal 12-volt. supply and the above option is only for special situations.

For highest sensitivity, switch 1 (long polarize) will help. In addition, switch 4 (3 reading average) used with or without switch 1 will again increase signal to noise ratio. Because of the lengthening of the total cycle time needed to perform 3 count averaging, this setting is probably most applicable to base station recording.

Because of the increased power needed to perform 3 reading average (when switch 4 is on), you should consider using alkaline batteries, or external power if switch 1 (long polarize) is also used. The standard batteries supplied with the G-856 will not last through the time it takes to fill the memory when 3 count averaging is being applied.

In summary, proper selection of the polarize and count options will require some judgment on the part of the user, but having this flexibility can produce better data under difficult condition.

<u>Switch </u>5 (Display off after 5 minutes auto cycle)

Switch 5 is applicable to the AUTO mode. In some uses of automatic recording, it will be desirable to have the readings displayed as they are taken and stored. Typically would be for portable surveys where the operator wishes to automatically record (to save button pushing and to increase the number of readings storable), yet wants to monitor the operation. But, in other cases, base station recording for example, there would be no value in lighting the display, since the display uses about half the power consumption and the system is operated unattended.

Setting Options Switch 5

If switch 5 is turned on, the display will blank if the keyboard is not exercised for five minutes. When you first set up the instrument, the display will light for five minutes to allow initial monitoring of the operation, but after you leave and those minutes have elapsed, the display will shut down to save power.

If switch 5 is off, the display will continue to light each cycle indefinitely.

SWITCHES 6, 7, AND 8 (BAUD RATE)

Switches 6, 7 and 8 are used to set the baud rate. The RS-232 interface will output data at selected speeds, called the baud rate. Different types of devices can send and receive at different rates or combinations of rates. A mechanical teletype with an RS-232 interface will receive at 110 baud. A standard telephone line with a modem will communicate at 300 baud. Printers with RS-232 interfaces may handle 300 or 600 baud (and others). Computers, of course, can handle high speeds of data transmission at 9600 band. The data handling device that you connect to the G-856 will either have a specified baud rate or a selection of baud rates. You will want to use the fastest combination available between the two instruments, but they must be set to the same baud rate to transfer data.

The data transfer rate in characters per second is approximately one/tenth the baud rate. A reading contains about 30 characters (FIELD, TIME, STATION NUMBER, DAY, LINE NUMBER, spaces, punctuation marks, carriage returns, line feed, and some null characters to allow time for the mechanism to return to the start of a new line). That means that a single reading will require as much as three seconds to print on a slow telex machine, or as little as l/5 of a second to feed into a computer.

Figure 9 and Table C-1 (Appendix B) show the switch option settings.

Figure 9
Switch Setting Options

SWITCH		S1	S2	
1		OFF	OFF	NORMAL
	POLARIZE TIME	ON	OFF	LONG
2		ON	ON	SHORT
		ON	ON	SHORT
3	READ TIME	OFF		NORMAL - 920 ms
		ON		SHORT - 460 ms
4	3 READING AVERAGE	OFF		NORMAL
		ON		AVERAGE
5	AUTO CYCLE	OFF		NORMAL
	DISPLAY	ON		DISPLAY SHUTS DOWN
6	BAUD RATE SELECT (See Table C-1)			
7				
8				

L. USING THE RESET SWITCH

There is a small red and white push button reset switch in between the circuit boards on the left hand side of the instrument chassis. Should the instrument experience a processor lock up, it may be necessary to reset the G-856. Care should be taken when using this switch as all memory and internal settings such as the Clock and Cycle times will be reset to default settings. Make sure you attempt to download the data prior to using this switch.

M. SPECIFICATIONS

Displays	Six digit display of magnetic field to resolution of 0.1 gamma or time to nearest second. Additional three digit display of station, day of year, and line number.
Resolution	Typically 0.1 gamma in average conditions. May degrade to lower resolution in weak fields, noisy conditions or high gradients.
Absolute Accuracy	One gamma, limited by remnant magnetism in sensor and crystal oscillator accuracy.
Clock	Julian clock with stability of 5 seconds per month at room temperature and 5 seconds per day over the temperature range of -20 to +50 degrees Celsius.
Tuning	Push button tuning from keyboard with current value displayed on request. Tuning range 20 to 90 kilogammas.
Gradient Tolerance	Tolerates gradients to 1800 gammas/meter. When high gradients truncate count interval, maintains partial reading to an accuracy consistent with data.
Cycle Time	Complete field measurement in three seconds in normal operation. Internal switch selection for faster cycle (1.5 seconds) at reduced resolution or longer cycles for increased resolution.
Manual Read	Takes reading on command. Will store data in memory on command.
Memory	Stores more than 5000 readings in survey mode, keeping track of time, station number, line number day and magnetic field reading. In base station operation, computes for retrieval but does not store time of recording designated by sample interval, allowing storage of up to 12,000 readings.
Output	Plays data out in standard RS-232 format at selectable baud rates. Also outputs data in real time byte parallel, character serial BCD for use with digital recorders.
Inputs	Will accept an external sample command.
Special Functions	An internal switch allows: 1) adjustment of polarization time and count time to improve performance in marginal areas or to improve resolution or speed operation, 2) three count averaging, 3) choice of lighted displays in auto mode.

Physical — Instrument console: 7 x 10 ½ x 3 ½ inches (18 x 27 x 9 cm) 6 LB (2.7 kg)
Sensor: 3 1/2 x 5 inches (9 x 13 cm) 4 LB (1.8 kg)
Staff: 1 inch x 8 feet (3cm x 2.5m) 2 LB (1kg)

Environmental — Meets specifications from 1 to 40°C. Operates satisfactorily from -20 to 50°C.

Power — Operates from 9 D-cell flashlight batteries (or 13.5 volts external power). May be operated at 18 volts external power to improve resolution. Power failure or replacement of batteries will not cause loss of data stored in memory.

ACCESSORIES

Standard:
- Sensor
- Staff
- Backpack
- Two sets of batteries
- Carrying case
- Applications Manual for Portable Magnetometers
- RS-232 Cable

Optional:
- Cold weather battery belt
- Rechargeable Battery option
- 50' External power / Sensor cable
- Spares Kit

APPENDIX A

Operation Short Reference Guide

1) Clearing a key sequence [CLEAR]

2) Taking and Storing a Reading [READ] [STORE]

3) Recalling from Memory --last reading taken
[RECALL] (continue pressing RECALL to decrement memory location, press ENTER to increment memory location)

4) Recalling from Memory --specific station number

[RECALL] [SHIFT] [(station) #] [(station) #] [(station) #] [ENTER]

5) Tuning the magnetometer

[READ] [TUNE] [SHIFT] [TUNING #] [TUNING #] [ENTER]

6) Erasing data -- last reading

[READ] [RECALL] [ERASE] [ERASE]

7) Erasing Data -- last group of readings

[RECALL] [SHIFT] [(station) +] [(station) +] [(station) +] [ENTER]
[ERASE] [ERASE]

8) Erasing Data -- entire memory

[RECALL] [SHIFT] [0] [ENTER] [ERASE] [ERASE]

9) Time and Line Number Display

[TIME] (press while reading is being displayed -- see RECALL)

10) Line Number Set

TIME	SHIFT	(line) +	(line) +	(line) +	ENTER

11) Julian Day set

AUTO	TIME	SHIFT	(day) +	(day) +	(day) +
ENTER					

12) Julian Day and Time Set

AUTO	TIME	SHIFT	(day) +	(day) +	(day) +
(hour) +	(hour) +	(minute) +	(minute) +	ENTER	

13) Output Initiate

OUTPUT	ENTER

14) Output Stop

OUTPUT	CLEAR

15) Setting Auto Mode

AUTO	SHIFT	(seconds) +	(seconds) +	ENTER

16) Auto Mode Off

AUTO	CLEAR

Appendix B

OPERATING THE MODIFIED MODEL G-856 (UNITS HAVING SERIAL NUMBER 27351 AND ABOVE, AND USER-MODIFIED UNITS) AND THE MODEL G-856X

Because of several performance improvements included in the (1) Model G-856X, (2) later models of the Model G-856, and (3) instruments that have been retrofitted to upgrade their performance*, the operating procedures of these instruments differ from those of the earlier, unmodified Model G-856 magnetometers. This appendix describes these performance improvements and the new operating procedures.

Beeper/Annunciator

The beeper/annunciator sounds once each time a key is touched, three times after data from memory have completely transferred through the RS-232 output, and five times whenever high gradients or noise are detected.

Julian Date Display

To distinguish a Julian date from a line number, each Julian date is displayed with a trailing decimal point in all modes (DISPLAY, RECALL, etc.).

Expanded Baud Rate Selection

Table B-1 lists the expanded baud rate selection and the programming switch settings required to configure the magnetometer for a specific rate. Note that Switch 8 is now operable.

Table B-1

BAUD RATE SELECTION

Baud Rate	Programming Switch Setting		
	Switch 6	Switch 7	Switch 8
110	OFF	OFF	OFF
150	ON	OFF	OFF
300	OFF	ON	OFF
600	ON	ON	OFF
1200	OFF	OFF	ON
2400	ON	OFF	ON
4800	OFF	ON	ON
9600	ON	ON	ON

* Two retrofit kits are available: Kit 16640-O1 upgrades an earlier model G-856 to have the newer software features described in this appendix. Kit 16640-02 will essentially convert a Model G-856 to a Model G-856X, complete with expanded memory.

Operation in the Base Station (Auto Cycle) Mode

Table B-2 is a listing of the functions that can and cannot be executed in the base station (auto cycle) operating mode.

Table B-2

BASE STATION MODE (AUTO CYCLE) FUNCTIONS

Allowed Functions	
RECALL	(recalls stored readings)
TUNE	(tunes the magnetometer)
TIME	(displays time and line number)
AUTO-TIME	(displays time and Julian day)
AUTO-TUNE	(enters or exits auto-tune mode)
AUTO-TUNE-SHIFT	(adjust cable capacitance)
AUTO -ERASE	(enters or exits auto-erase mode)
Disallowed Functions*	
OUTPUT	(outputs data)
READ	(takes a reading)
STORE	(stores reading)
AUTO-ENTER	(enters auto cycle)
AUTO-TIME-SHIFT	(changes time or Ray)

*If an attempt is made to activate a disallowed function, the display will read out

Auto	FIELD/TIME
Err	STATION/DAY

Faster Cycling In Base Station (Auto Cycle) Mode

As shown in Table B-2, single and three-cycle-averaged times for operation in the base station mode have been reduced by approximately one second for all polarization and reading (gate) configurations. The table breaks out the selection of cycle time and the appropriate programming switch configurations.

Table B-3

CYCLE TIME SELECTION

Single Cycle (seconds)	Three-Reading Average (seconds) (switch 4 ON)	Switch 0 (Long Pol, if ON)	Programming Switch Setting Switch 1 (Short Pol)	Switch 2 (Short Gate if ON)
4	10	OFF	OFF	OFF
5	13	ON	OFF	OFF
3	7	OFF	ON	OFF
3	7	ON	ON	OFF
3	7	OFF	OFF	ON
4	10	ON	OFF	ON
2	6	OFF	ON	ON
2	6	ON	ON	ON

Memory Operation

The Model G-856X has a memory capacity of 12,000 readings taken in the base station operating mode or 5,700 readings taken in the field reading operating mode. Models with serial numbers of 27351 or greater have a memory capacity of 2,950 base station readings and 1,450 in-the-field readings. Note that you have the additional option of specifying a G-856X memory for retrofitting your early model G-856 to maximum memory capacity.

A reading is stored in memory when the STORE key is pressed after a reading is made. To indicate that a reading has been stored,

STORED Field/Time is displayed

To erase a reading recalled from memory and all readings following that reading, the ERASE key is pressed twice while the recalled reading is being displayed. The display will change to *ERASED* Field/Time.

By continuously depressing **ENTER** or **RECALL** key when recalling readings, the readings will be automatically reviewed at an increasing rate; for example, the read out rate will start at one reading every half second, then increase within 10 seconds to 5-6 readings every second.

DATA FIELD / TIME. Should data in memory become corrupted
Err STATION / DAY will be displayed whenever a key is depressed. However, even though this message is displayed, most keystroke sequences are valid. If the stored data are not totally corrupted, the stored information may still be reviewed or output to an RS-232 device to recover the remaining uncorrupted data. Once the data have been recovered the **ERASE** key can be depressed twice to reset the instrument and completely clear the memory. See note on page 17

One way that memory may be corrupted is by removing power (either by disconnecting an external power device or by removing the internal batteries) while the G-856 is in an operating mode; e.g., auto cycle. In most cases only the last reading will be affected, so the remaining stored data should be transferred to a storage device (a computer or recorder). This transfer must be done before the ERASE ERASE sequence is followed or all of the data in memory will be lost. Until the error is cleared, you will not be able to reactivate the auto cycle mode.

Tuning

Tuning is accomplished automatically. When the automatic tuning function is activated, the tuning value is automatically updated after each field reading--unless a high gradient is being read. To activate the automatic tuning function press:

AUTO **TUNE** **ENTER**

This key sequence will activate the following displays:

Auto	FIELD/TIME	*A tunE*	FIELD/TIME
x x	STATION/DAY	*oFF*	STATION/DAY

While the automatic tuning function is enabled, the instrument cannot be manually tuned. The tuning value and signal level may be displayed but they cannot be changed. Attempts to manually tune the instrument will produce this display:

A tunE	FIELD/TIME
Err	STATION/DAY

Note: For best performance, manual tune the G-856 before taking the first reading of a survey area, then activate the automatic tuning function.

To deactivate the automatic tuning function

| AUTO | TUNE | CLEAR |

The display will be:

Auto	FIELD/TIME	*A tunE*	FIELD/TIME
x x	STATION/DAY	*on*	STATION/DAY

To determine whether the instrument is in the automatic running mode, press AUTO TUNE The display will indicate whether the automatic tuning is on

	A tunE	FIELD/TIME
	on	STATION/DAY
Or off	*A tunE*	FIELD/TIME
	off	STATION/DAY

To ensure the optimum performance of the automatic tuning function, the magnetometer tuning value should be matched to the capacitance of the sensor cable. Most Geometrics cables for portable sensors have a capacitance of .03 nano-farads per foot; thus, the standard portable sensor cable supplied with the G-856 has a total capacitance of 0.2 nano-farads. To match the instrument's automatic tuning function to this standard cable, press

| AUTO | TUNE | SHIFT |

The display will read

Auto	FIELD/TIME	*A tunE*	FIELD/TIME
X X	STATION/DAY	*on* (or off)	STATION/DAY
CAP	FIELD/TIME	*CAP*	FIELD/TIME
X X X	STATION/DAY	— — - —	STATION/DAY

Key in the capacitance of the sensor cable

[SHIFT] 0 [SHIFT] 0 [AUT]O

and press [ENTER]

Addendum to Memory Operation'

In the field mode, a reading can be taken and automatically stored each time

READ is depressed. To enter the auto store mode, depress the following keys:

[AUTO] [STORE] [ENTER]

To clear the auto store mode press:

[AUTO] [STORE] [CLEAR]

In the base station mode the G-856X can be configured to take readings even if the memory is full. In this auto erase mode, the earliest sixteen stored readings will be deleted and the instrument will continue to take readings. To enter the auto erase mode, depress the following keys:

[AUTO] [ERASE] [ENTER]

To clear the auto erase mode, depress:

[AUTO] [ERASE] [CLEAR]

To determine if either the Auto Store or the Auto Erase feature is ON or OFF, press

[AUTO] Then press either [STORE] or [ERASE]

The display will indicate whether the feature is ON or OFF.

APPENDIX C

G-856 GRADIOMETER OPTION INSTRUCTIONS

1. PURPOSE

The G-856 Gradiometer Option allows a single G-856 chassis to take successive reads from two vertically separated sensors. The result is a measurement of vertical gradient independent of time variations. See Note 1.

2. CONTENTS

This option consists of a Remote Start Switch Box, two special sensor cables, a special second sensor, a staff modification kit, and a Velcro strip.

3. PREPARATION

Configure the G-856 console for normal polarize, normal gate, 9600 Baud data transfer and disable 3 read averaging by setting switches 1 through 4 to "off" and 6 through 8 to "on" on the G-856X CPU board.

Assemble the staff and sensors. Start by removing the standard cable from the original sensor and attaching one of the special sensor cables. Next, connect the staff modification kit parts to the top of one staff section and the bottom of another staff section so that the threaded shafts point towards each other. The second sensor, with two threaded caps, will mount between the two staff sections. Sensor separation may be controlled by choosing an appropriate pair of staff sections.

Typical sensor separation will be two staff sections or 4 ft. Thus the top sensor will be at 8 ft and the lower sensor at 4 ft. Care must be taken not to allow the lower sensor to come close to the console (hold at arms length) due to the magnetic effects of it's circuitry and batteries.

Then assemble staff sections and mount the sensors. The sensor cables may now be connected to the Remote Start Switch box, and the Remote Start Switch may be connected to the G-856 front panel connector. Attach the Velcro strip to the top of the G-856 black front panel bezel. Mount the Remote Start box to this mating Velcro strip.

4. OPERATION

To initiate a gradiometer read cycle, depress the Cycle button on the Remote Start Switch. The G-856 will then take two readings, the first from the bottom sensor, and the second from the top sensor. Data will be automatically stored.

5. DATA STORAGE

Gradiometer readings are stored as pairs of field readings. Assuming that the G-856 memory were cleared before operation as a gradiometer, reading 000 would be from the bottom sensor reading and 001 would be the first top sensor reading. From then on, each even numbered reading will be from the bottom sensor and each odd numbered reading will be from the top sensor. The RS-232 output format is described on page 35 of this G-856 manual. MagMap 2000 automatically separates these interleaved readings into two data files

Note 1:

Since readings taken using the gradiometer Box are treated by the magnetometer as external cycles, the internal memory pointer is not updated. Therefore pressing "Recall" may not display the last reading as with internal operation. To view the last reading taken in gradiometer mode press "Recall" "Shift". Then enter a number equal to or greater than the last reading. When erasing a gradiometer station, the last two readings must be erased.

Note 2:

In situations where changes in the earth's field are significant during the interval between sensor reads, some correction of the data will be necessary.

WARRANTY AND SERVICE

Warranty

Geometrics full warrants the Proton Precession Magnetometer to be free of defects in material and workmanship for a period of one year from the date of acceptance. Geometrics maintains good commercial practices in the manufacture of equipment. In the event of malfunction, Geometrics, at its own expense will repair or replace any material, equipment, work, or parts that prove defective or deficient under normal operating conditions.

Except for the express warranty stated above, Geometrics disclaims all warranties of merchantability and fitness, and any stated express warranties herein are in lieu of all obligations or liability on the part of Geometrics for damages, including but not limited to special, indirect or consequential damages arising out of, or in connection with the use or performance of the equipment.

Geometrics reserves the right to perform warranty services FOB San Jose or at the customer's installation site. Geometrics is not responsible for delays or defects in the quality of results from misuse, mishandling, unauthorized modifications, installation, or other operation conditions out side its control.

Should warranty service or technical advice be required, contact Geometrics. No warranty service will be performed unless the customer secures authorization from Geometrics prior to returning equipment. If this instrument or any part of it is returned to the factory for any reason, please complete this form and include it with the instrument or part being returned.

SHIP TO:

Geometrics Inc.
2190 Fortune Drive, San Jose, CA 95131
Phone: (408) 954-0522
Fax: (408) 954-0902

(For international shipments use
San Francisco International Airport,
Attention: KEL International 650-697-6400)

Name

Company

Address

City, State, Zip, Country.

Telephone

IMPORTANT

Please explain why this instrument or part is being returned; include a complete description of any malfunction (use additional paper if necessary). Thank you.

Appendix B

G-859 Manual

G-859 MINING MAG
Cesium Vapor Magnetometer

Operation Manual

P/N 25309-OMM

GEOMETRICS, INC.
2190 Fortune Drive, San Jose, CA 95131 USA
Phone: (408) 954-0522
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CE

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December 3, 1996

Sunnyvale, California, USA

EC DECLARATION OF CONFORMITY

We, Geometrics, Inc.
Geometrics Europe
395 Java Dr.
Sunnyvale, CA 94089 USA ph:
(408) 734-4616 FAX: (408) 745-
6131

declare under our sole responsibility that our portable magnetometers, models G-859 to which this declaration relates are in conformity with the following standards:

EN61010-1 :1993/A2: 1995

per the provisions of the **Low Voltage Directive** ***73/231EEC*** of 19 February 1973 as Amended by *93/68/EEC, Article 13* of 22 July 1993 and,

EN 55022: 1995, EN50082-2 : 1995, ENV 50140: 1994, ENV 50141 :1994, EN 61000-4-2: 1995, EN 61000-4-4: 1995

per the provisions of the **Electromagnetic Compatibility Directive** ***8913361EEC*** of May 1989 as Amended by *92131/EEC* of 28 April 1992 and *93/68-EEC, Article 5* of 22 July 1993.

The Technical documentation required by Annex IV(3) of the Low Voltage Directive is maintained by Christopher Leech of Geometrics Europe (address below).

The authorized representative located within the Community is:

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Steven W. Duckett, President, Sunnyvale, CA, USA

Warning

This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

Table of Contents

Chapter 1: Introduction

Overview

The model G-859 Mining Mag is a professional quality magnetic mapping tool offering exceptional speed and efficiency. The system in configured for use in the geological context, for producing detailed magnetic maps for exploration of minerals, oil/gas, diamonds and man-made structures. Data is stored in non-volatile memory for playback review and downloading into a host PC. The system includes a comprehensive software package to download, edit and interpolate magnetic data into 2D or 3D contour-ready formats. Hard copy annotated color maps can be produced within minutes after data transfer to the base computer.

The G-859 includes three unique features, each intended to assist the collection of magnetic data. First, the system lets you visualize the survey area beforehand in X-Y space, entering in the desired survey corner location points. Second, it lets you review your locations and your data during the survey. The system presents a "Quick Look" to the operator of up to 5 stacked survey profiles for quality control purposes. Finally, the unit allows you to edit X-Y position and magnetometer data, both in the field and in later processing.

Figure 1 G-859 with sensor at 45 deg

Applications

The G-859 Mining Mag is primarily used for exploration programs for minerals, oil, gas, diamonds and geologic survey. It can also be used to locate waste dumps, buried drums or other underground storage containers; to find pipelines, well-heads and other utilities; to study geological structures and faults. The fast response of the instrument means that the data may be taken at a brisk walking pace which efficiently covers four to ten times as much ground per hour as non-cesium magnetometers. The high sensitivity means that many potential targets which would have been missed with other techniques will stand out clearly and unambiguously.

Features

The G-859 has been designed to greatly simplify magnetic surveying. All of its features are intended to speed up the surveying process and reduce the possibility of mistakes. Toward that end, the following features have been incorporated into the G-859:

- Continuous surveying, where the unit automatically records data at a user-selectable rate, up to 5 readings per second (Note: Newmont rate is 10 Hz).
- Integrated NovAtel Smart Antenna™ GPS system is preconfigured, Lat/Long data recorded simultaneously with the magnetic data. Used to produce a located survey map and exportable interpolated data set using the supplied MagMap2000 program.
- Audible tone indicating goodness of GPS fix
- Discrete surveying option where the unit takes a reading upon an operator key-press.
- Four modes of operation: search mode, for performing a random search for anomalies or system test; simple survey, for a simplified method of operation with Line and Station marking; mapped survey, for the full capability of defining X-Y location and tracking position as readings are taken; and base station, for collecting data to be used for diurnal corrections.
- Real-time analog waterfall display of the current magnetometer reading.
- Up to five separate surveys may be stored independently for up to 6 to 8 hours of recorded data with GPS.
- Map display showing the X-Y survey area, with readings plotted in the correct X-Y locations.
- Data profile displays, allowing previous data to be reviewed on line by line basis.
- Data editing capability, where data may be deleted and retaken.
- Downloading of data in compressed format to a host PC.
- MagMap2000 software for editing data positions, GPS positions, doing diurnal corrections, filtering, de-spiking, de-striping and drawing profiles and contour maps.
- Writing a out a file for plotting profiles and surface contours with Geometrics or 3rd party software, such as MagPick, Surfer or GeoSoft.
- Audible tones indicating the field change over the local target, warning of non-valid data, indicating that data was taken and stored, and that location keys have been pressed.
- Storage capacity for more than 250,000 readings and positions, each recorded with the time of the event and position, including externally logged GPS positions.
- Logging of user-defined field notes.

Modes of Operation

Here we present an overview of the modes of operation, along with their advantages and when each should be used.

GPS Survey Mode

Used in conjunction with either Simple Survey or Mapped Survey mode described below, the magnetometer receives GPS transmissions at regular intervals (typically every 1 second) and stores those positions along with the magnetometer data acquired at a 1, 2 or 5 Hz rate. When downloaded into the supplied MagMap2000 program, the GPS positions are interpolated so that each magnetometer reading is assigned a GPS position. GPS data reception is signaled by a blinking RS-232 display box.

Search Mode

In Search mode, the magnetometer operates normally, displaying an analog oscilloscope-like trace, with an audible sound whose pitch indicates changes in the field reading (the "woowee" indicator). However, data is not stored in memory. This is useful for manually identifying anomaly locations, much as with a metal detector. It is also useful to check for proper sensor operation, ambient magnetic noise and the magnetic cleanliness of survey operator accessories such as shoes, belt buckles, keys etc.

Simple Survey Mode

This is the recommended mode for use with the Novatel GPS. In simple survey mode, the unit keeps track of MARK (start line, and waypoints) and END LINE (end of line) key presses, and the direction of each line. This allows a full and complete survey. Later, after downloading the data into the PC, the MagMap2000 program will attach an x and y coordinate to each reading.

Simple survey mode allows the simplest operation of the G-859, enabling the operator to easily assign X-Y positions in the supplied MagMap2000 software. You must manually keep track of where you are taking data, and enter this information into the host software to locate the readings.

Simple survey mode lends itself to interfacing to the integrated Novatel GPS system which transmits position data as a $GPGGA string to the G-859 Console. MagMap2000 allows positioning of the data in either rectilinear X-Y and GPS mode.

Mapped Survey Mode

Mapped survey allows you to visualize the survey area more completely than in simple survey mode and move around within the area in a non-contiguous fashion. Using the arrow keys, you may position the cursor anywhere within the map and acquire data. Default cursor movements are programmed into the unit, so if you follow a normal path across the survey area, you may simply press the MARK and END LINE keys as if you were doing a simple survey.

This method allows the easiest operation of the PC host software. You must enter more information into the G-859, however. This mode will track your X-Y position for you automatically, assuming you are following a simple path, while also allowing you to change your position manually, when, for example, you reach an obstruction and wish to start again on the other side.

Base Station Mode

In base station mode, the unit will not keep track of changes in position. This is most useful when the unit is being used to collect data for diurnal correction. Both data and the time of the readings are stored in internal memory.

In addition, this mode supports a real-time transfer of data out of the RS-232 port as it is being acquired. This is useful if you are using another PC to collect and process the data, for instance, when using the G-859 from a mobile platform. Of course, you may also store the data inside the G-859, with or without real-time transfer.

Magnetic Surveying Checklist

Here we give a quick checklist for performing a magnetic survey. Please see Appendix 1 if you are unfamiliar with magnetic surveying. Subsequent chapters will explain in detail the operation of the G-859 during the survey and of use with the Novatel GPS (See Chapter 9). GPS data is automatically stored and later interpolated to provide a position for each magnetometer reading. The following sections refer to operation in X-Y positioning mode only. X-Y data positioning can be used as a backup to GPS positioning.

1. Setting up the survey grid

- Designate an individual to be responsible for making a sketch of the survey site, with notes and comments on all relevant objects such as power lines, fences, pipes, and surface debris.
- Establish a base line, which will provide the start or end points for all profile lines. Designate the left hand corner of the base line to be (0,0) for the X and Y axes. Note that the survey lines can run in any direction, but if a choice exists, the preferred direction would be North and South.
- Using the smallest search target size, determine the separation of the profile lines. For small targets such as a one pound ferrous mass with worst case shape and orientation, lines spaced 2 meters apart is a good initial choice. For mining and geologic surveys, line spacing may be 50m to 100m or more.
- Place non-magnetic, brightly colored markers at the start and stop of each profile. If the lines are long or require irregular walking speeds, place a marker at regular intervals (perhaps each 20 or 50 meters) along the profile. These will become fiducial or waypoint entries in the data stream.
- If the survey is to be broken into separate but adjacent areas, it will help you to stitch the sections together if there is at least one profile line of overlap. Also insure that the profiles extend beyond the actual survey boundary by at least 2 or 3 times the estimated target depth.
- Locate the survey area corners and reference them to other surface objects. If the site will be relocated in the future, it may be useful to permanently mark the corners with an iron stake (re-bar) driven down to ground level. Note that these corner stakes are the only magnetic objects that are used on the entire survey site. Flags, cones, stakes and other markers must be carefully inspected to be non-magnetic.

2. Turn on and warm up the G-859 (about 2 minutes), using the procedure described in Chapter 2. Select the Search Mode, and adjust the sensor for the proper operating orientation, i.e. there should be continuous signal and correct instrument operation in all directions of the survey profiles. The program CSAZ will help to determine the best sensor orientation to avoid dead zones. Turn on the GPS if not already on. There is a switch on the battery compartment to power up the GPS. Remember to turn this off when the GPS is not in use.

3. Demagnetize the magnetometer operator. Using the G-859 in the Search Mode, insure that the operator does not contribute an error greater than 1 nT in any direction. (Refer to the Applications Manual, chapter 4 for a fast, simple, "magnetic swing" procedure that will measure the operator's magnetic cleanliness.) Pay particular attention to the operator shoes, eye glasses, and the removal of rings, keys, belt buckles, and all pocket items. Only a small amount of magnetic material is needed to seriously distort the magnetic data.

4. Select a survey "Test Profile" line. This profile should be run in each direction at the start and end of each survey day as a check of data repeatability and quality. It is an excellent check of proper system operation and may be useful as "proof of operation" to the end user.

5. Perform the data acquisition for all survey profiles and record the direction of each profile on the survey sketch map. Also record the start and end locations and the direction of the first and last survey profiles for each survey day. This may be duplication of effort, but is independent of the data logged in the instrument and may be very helpful in editing the data during processing.

6. During the course of the survey it is important that the operator has adequate support in finding and staying on the line. However, if the operator is disrupted during data acquisition, the G-859 easily allows data to be deleted and/or retaken. The G-859 has been designed to reduce mistakes and save money.

7. Finally, at the end of the survey, download the data to your host PC using the RS-232 download cable. Edit the positions if necessary, smooth GPS positions as required and plot the data in profile or contour map in MagMap2000. MagMap2000 also provides routines for

- Spike editing. Included a dropout removal tool and a "range despike" that removes any data spikes that exceed a graphical threshold drawn as a box around the profile data
- Spline filtering. A low pass or high pass adjustable filter is available to remove unwanted frequencies from the data. This enables the operator to remove surface clutter from geological map data for instance.
- De-Striping. This routine provides the ability to take a grid of data and greatly reduce heading error offsets sometimes seen when data collected in opposite directions on subsequent lines is contoured resulting in "corrugated" or striped data result.
- Diurnal corrections. This requires a secondary G-856 or G-859 magnetometer used as base station. It is critical that the clocks be synchronized in the two field instruments prior to survey, both date and time. Files from the roving and base station magnetometers are both loaded into MagMap2000 and the diurnal correction is applied on Export of the data to *.dat or *.xyz format (Surfer, MagPick or Geosoft formats). The *.dat file may be reimported into MagMap2000 to show the corrected data profiles.

Chapter 2: Assembly and Set Up

This chapter gives an overview of the entire surveying process. It will describe how to set up the instrument, operate in GPS / *Simple Survey* mode, and download the data into the PC for analysis. Please read Chapter 3 as soon as you can to find out more about your G-859 magnetometer.

Unpacking your G-859

The instrument is shipped in a rugged wheeled reusable shipping container, with each element carefully packed in an overlapping padded wrap or pouch. Unlock the case and fold out the padded packing wrap by pulling apart the Velcro as shown in Figure 2.

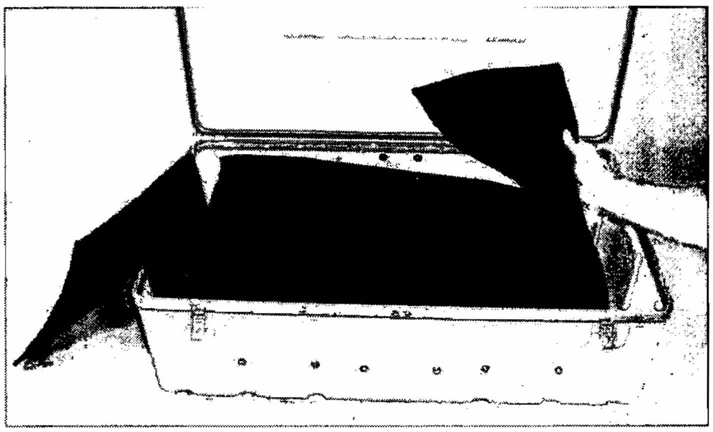


Figure 2 Shipping Container with Wrap

Carefully remove the console and the pack frame (backpack) with the GPS antenna and sensor mounted on their respective masts. Note that the second battery, charger, charger and data cables are in pouches in the front of the case. Inspect the parts list below and verify all components are in the shipping box.

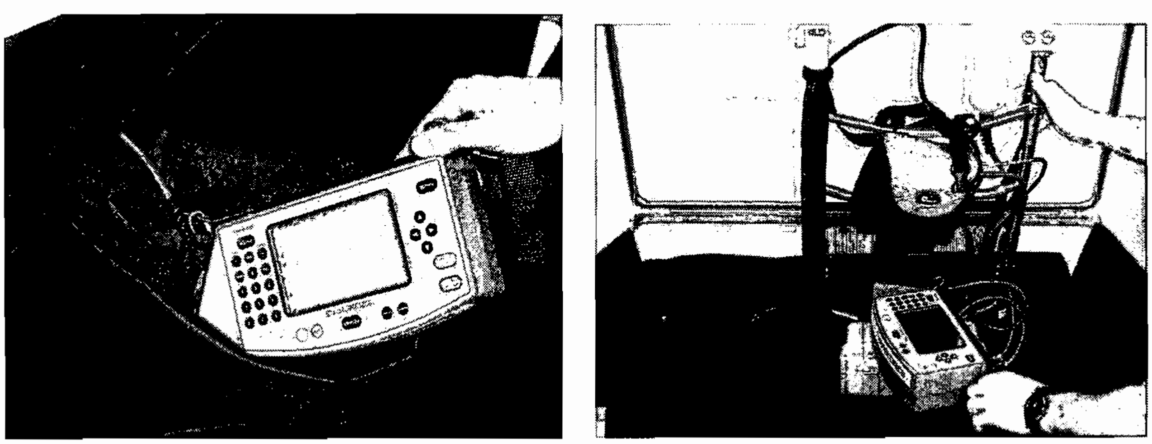


Figure 3 Remove Console from Pouch, lift pack frame from the padding

The tables below show the items that should be included.

Part Number	Name	Description
25306-20	Console with wired in sensor cable	Main magnetometer console, containing electronics, keypad, and display. Attached to pack frame
25307-20	Battery in pouch (2 included)	Battery pouch and mounting box for easy carrying of the system batteries.
25375-20	Novatel SmartAntenna GPS (system kit)	GPS is cabled with the battery pack and data logging console. Attached to the pack frame GPS mount
54101-01	GPS Mast Wrap	Use to secure GPS cable to mounting staff
54100-01	GPS Antenna Shroud	Padded pouch for GPS for protection
25450-99	Pack Frame	Back pack provides integrated cesium magnetometer and Novatel GPS. Provides mounting for GPS SmartAntenna, cesium sensor, batteries, 859 Logging Console and all cabling
27516-30	Sensor (includes sensor and is wired into console)	Measures the magnetic field. Mounted on the staff associated with the pack frame sensor mount
25555-01	Sensor clamp	Holds the sensor to the pack frame sensor mount
25555-02	GPS Mast clamp	Holds the GPS mast to the pack frame
25358-20	Serial data cable	Provides data transmission from G-859 to the PC
25366-03	Battery Charger	Recharges battery pack in about 6 hours
40-304-002	Adapter plug kit	Adapts charger to various AC power standards
18134-01	Application manual	Included on Magnetometer CD along with MagMap2000 and MagPick. Describes principles of magnetic surveying
25309-OMM	Operation manual	This document
24891-01	MagMap2000 PC software	Used to download data to host PC, modify positions, and write output files.
54050-01	Shipping case	For storage and shipping of the G-859 pack frame, console, sensor, batteries, charger and other accessories

Items included in G-859 Ship Kit.

Assembly of the Pack Frame components

Lift the Pack Frame and console free of the shipping container and set them on a table or clean surface. First, make sure the power cable is attached to the Console. It may have been removed during shipment. See figure 4 below

Figure 4 Insert Power Connector to G-859 Console

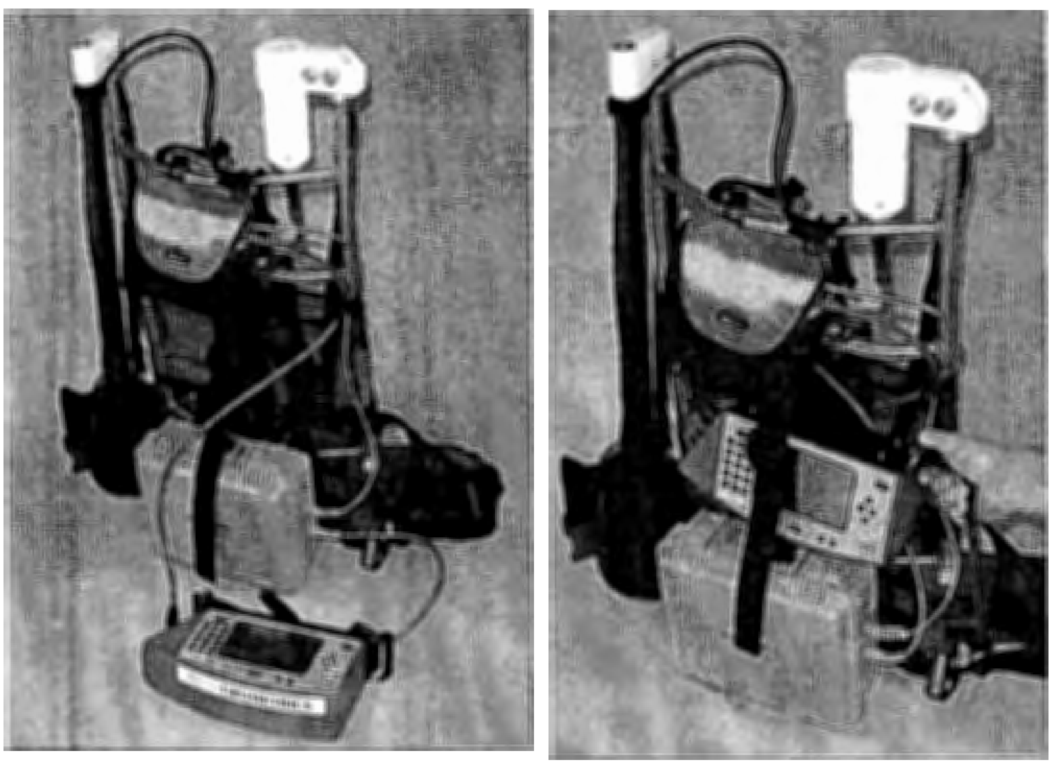


Figure 5 Store Console on pack frame for transport

Stowing the G-859 Console on the Pack Frame

For setup and transport, it will be convenient to slide the 859 console into the space above the battery box. Once the console is seated, tighten the vertical strap provided to keep it securely in place.

Cesium Sensor Adjustments

Next we will adjust the cesium sensor position. Note that the sensor may be mounted vertically, at 45° to the vertical and horizontally. Basically once you select the proper orientation for your area it will always mount in that manner. We suggest that you install and use CSAZ, a companion program on the Magnetometer CD that shows you how you should mount your sensor for any location on the globe. Suffice it to say that in the far northern and southern latitudes, the sensor will be mounted at 45°, for the mid latitude zones including as far south as Northern S. America you will mount the sensor vertically. In a narrow band about the earth's magnetic equator (not zero latitude necessarily) you will mount the sensor at 45° or horizontally with the top of the sensor tilted either North or South as you walk the survey line. See CSAZ for more information

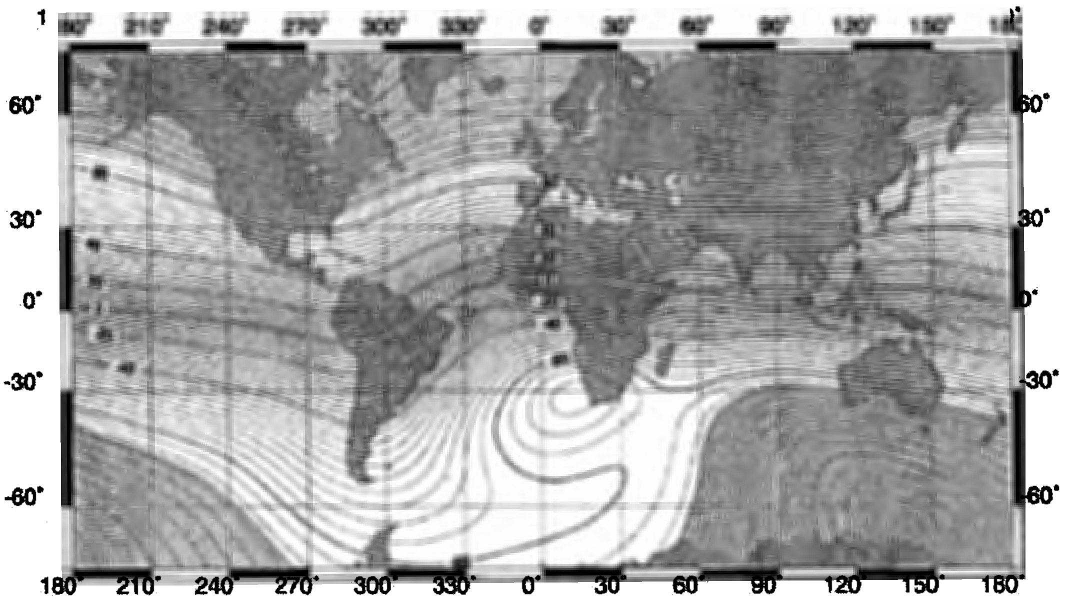


Figure 6 World map showing highlighted Vertical Magnetic field zone for 45 deg sensor mounting

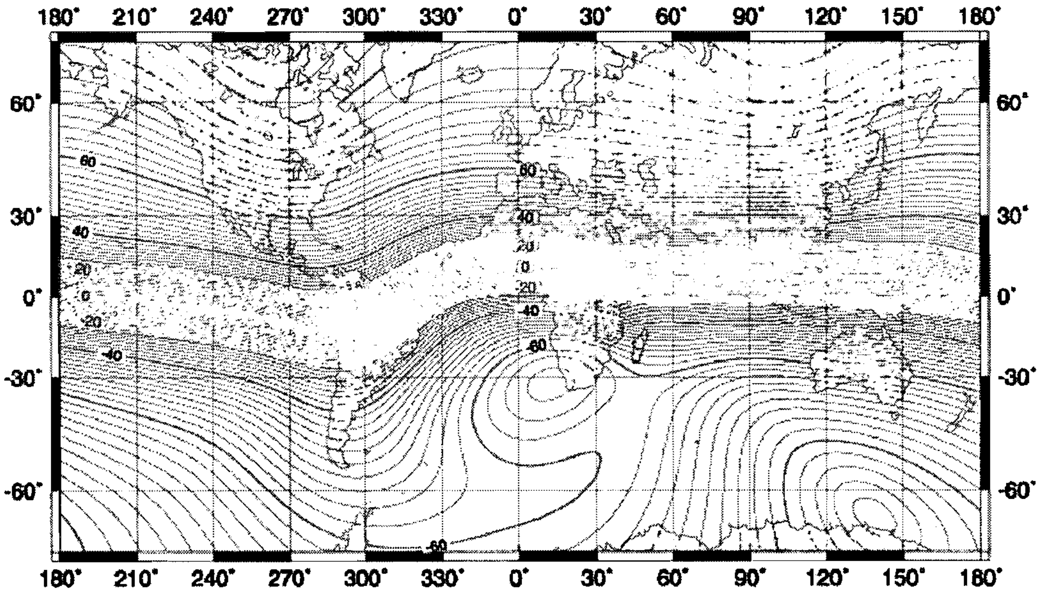


Figure 7 World map showing highlighted Horizontal Magnetic field zone for 45 or 90 deg mounting

Loosen the Sensor Clamp sensor knurled screw and push the sensor up until the bottom of the sensor is even with the clamp ring. Hand tighten screw. See picture below. Then remove the clamp screw holding the sensor clamp to the sensor mast. Rotate the sensor clamp 180° so that it extends laterally out to the right side of the pack frame as shown in Figure 9 and reinsert the sensor clamp screw and tighten. This is the proper installation for vertical orientation of the sensor.

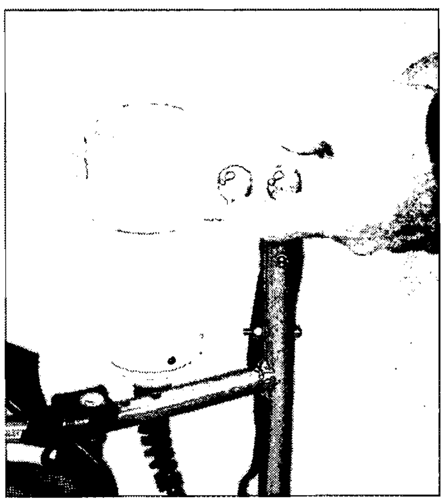


Figure 9 Sensor Body Clamp

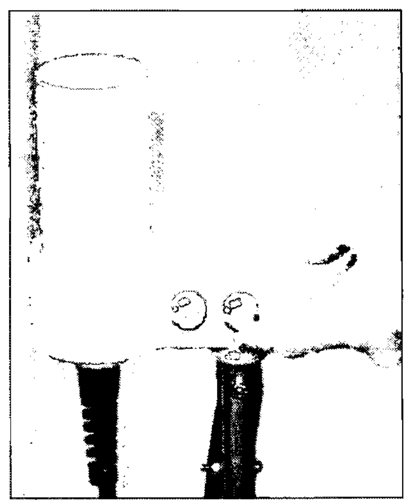


Figure 9 Sensor Mast Clamp

To orient the sensor for 45° or for horizontal operation, remove the Mast Clamp screw and place the clamp on the mast at 45° or 90° using the appropriate mast channel. See Figure 10 for examples of 45° and 90° installation.

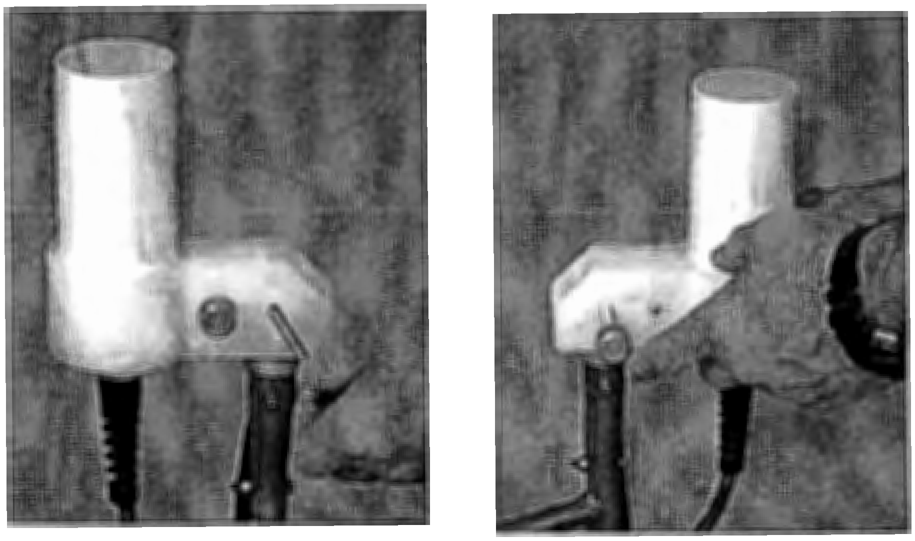


Figure 11 Remove Mast Clamp and swivel to right of pack frame

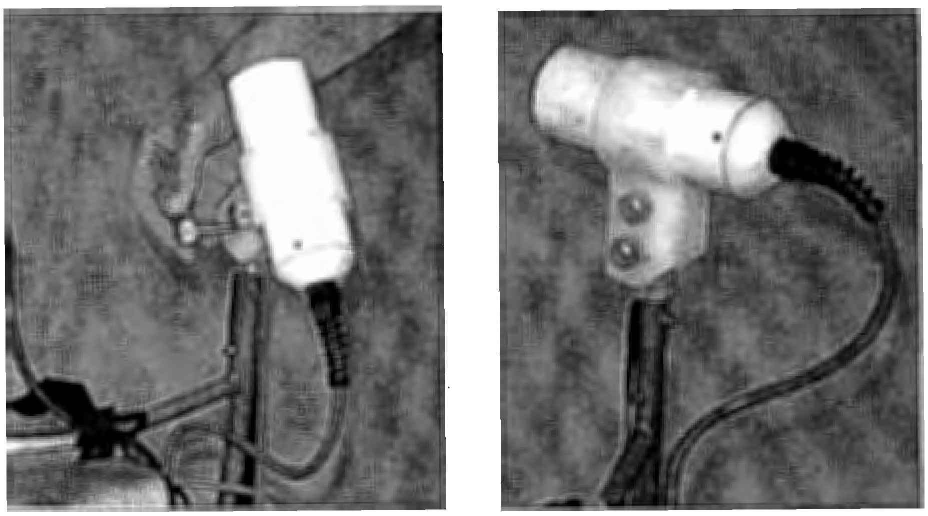


Figure 11 Sensor mounted at 45 and 90 deg

Installing the NovAtel Smart Antenna GPS™ mast

The GPS antenna mast has been mounted inside the pack frame for shipping. You must remove the antenna mast, rotate the clamp to the left to make the greatest lateral distance from the sensor mount, ensure the cable protection coverings are installed and then mount the antenna mast vertically on the left side of the pack frame.

Begin by loosening the antenna mast clamp screw and removing the antenna mast from the clamp as shown in Figure 12

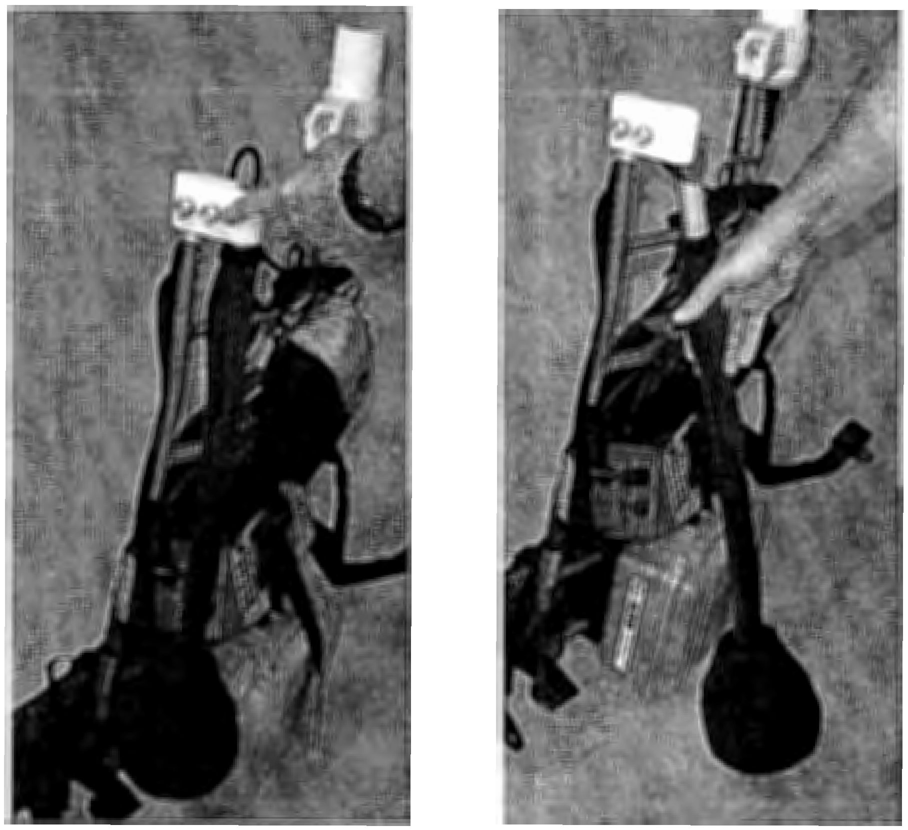


Figure 12 Remove Antenna mast from Pack Frame

Make sure the GPS cable wrap is securely fitted around the cable to prevent branches and brush from hooking on the GPS cable assembly. (Note: appearance of wrap material may vary). For a similar reason, make sure the Novatel SmartAntenna GPS antenna is covered with the black antenna shroud to protect the antenna and cable mount from branches and brush. See pictures below.

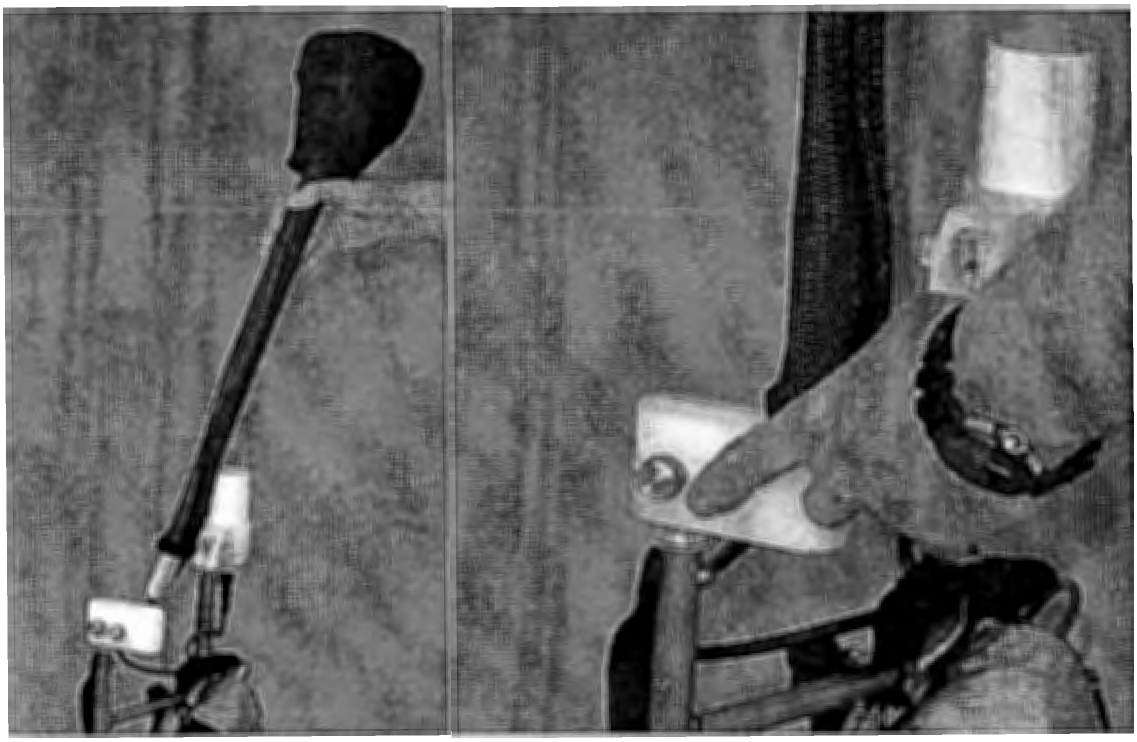


Figure 13 Insert Antenna Mast into clamp

The finished pack frame assembly is shown at the left in Figure 14. Note that the sensor and GPS mast are separated by the greatest lateral distance and that the antenna mast and sensor have their associated coverings. The cables may be further secured to the pack frame with small Velcro straps included in the shipping container.

Additional cable is provides in the cable bag should you need it. Effort should be made to limit the amount of exposed cable and subsequent snagging on branches which will occur during normal survey operations. Stow as much cable in the cable bag as possible.

The assembled pack frame is now ready for battery installation or battery replacement. The following section describes this process. After battery installation the system is ready for transport to the survey start point or for mounting on the survey operator.

Figure 14 Completed Pack Frame ready for transport

Battery Installation

The battery packs were fully charged before leaving the factory, but depending on storage time, they may need to be recharged. The system may come with the one of the battery packs pre-installed in the pack frame box. In this case you will check the voltage of the battery pack using the G-859 console battery meter (you must turn on the G-859 to see the meter reading). Recharge time is approximately 6 to 8 hours per battery. The battery may be recharged in the pack frame battery box using the standard charger cable.

Locate one of the special 24 VDC magnetically compensated battery packs is its carrying pouch. Lift the battery by its carrying strap and set it next to the pack frame. You will need to lean the pack frame assembly against a vertical support (tree or vehicle) while you install the battery. Open the G-859 battery compartment and set the battery on the open cover.

Inspect the connectors in the battery compartment and on the battery and note that they are keyed so that they can mate in only one orientation. Line up the keyed sections and firmly push the connector together. There is no locking sleeve, the friction of the rubber components will hold the connector together.

Lift the battery pack and slide it into the battery compartment, taking care to position the connector above the battery pack. When the battery is seated in the compartment, close and lock the battery box with the snap clasps.

Batteries will power the G-859 and Novatel GPS for between 5 and 7 hours depending on operating temperature. Cold temperatures will decrease battery capacity and increase magnetometer current requirements. Note that in very cold areas, the cesium sensor should be enclosed in an insulating jacket to keep heat loss to a minimum and extend battery life.

There is a small toggle switch on the top of the battery box for turning on the GPS. Remember to turn this switch on prior to mounting the pack frame on the operator!

NOTE To best maintain battery life, you should periodically charge the batteries (about every 4 months) if the unit is not in use.

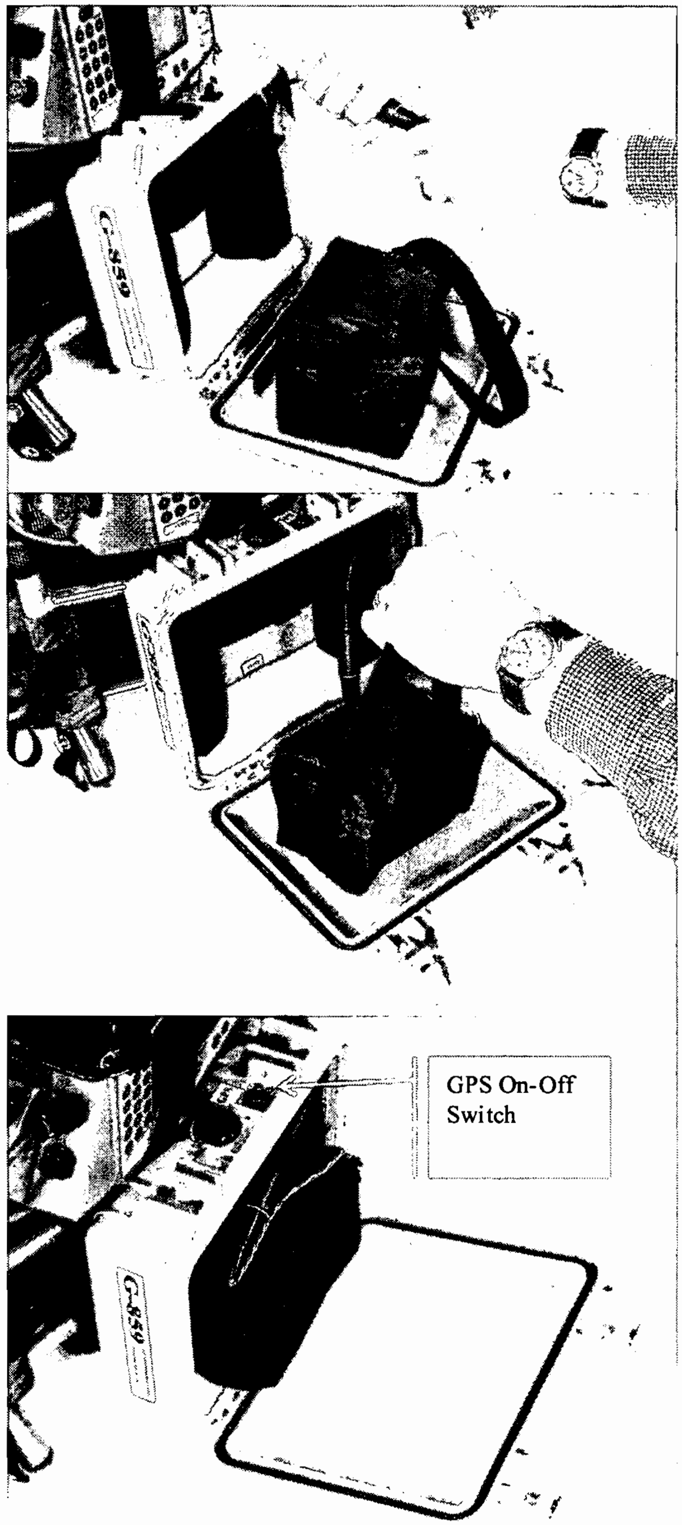


Figure 15 Battery Installation procedure

Adjusting the Pack Frame

The first time the pack frame is assembled and used, it will be necessary to adjust it for the individual user. This may require a second person to observe and make adjustments to the fit while the system is worn by the survey crew member. The pack frame is a professional grade frame with several different strap adjustments available. In addition, the frame itself is made of telescoping vertical poles that allow the frame to be extended or compressed for different sized individuals.

The pack frame commercial hardware has been replaced with brass and aluminum parts, removing all ferromagnetic components to keep the system magnetic self-signature to a minimum, thus reducing heading error and other platform noise. Never replace hardware with untested bolts, nuts or rings. Always test the hardware first by turning on the magnetometer and moving the hardware under test near the sensor. Typical goals are to have less than 0.5nT effect at 2 feet (0.6m) from the sensor.

The brass bolts on the vertical frame poles should be adjusted such that the shoulder straps start approximately 3 inches (7 cm) below and behind the shoulder. If the straps are too high the weight of the pack will not be on the shoulders, remove the brass bolts and shorten the vertical poles. If the straps are too low the straps will not adjust in the front. Then lengthen the vertical poles. See photo below for brass scew location.

If you need to extend or compress the pack frame, remove all 4 brass bolts and nuts and slide the pack frame tubing into or out of the mating tubing to get the proper height. You may have to loosen the back support webbing to get to the screws and to reposition the tubing. Reassemble the pack frame using the same bolts and nuts. Remember that any hardware not supplied by Geometrics is possibly contaminated with ferrous materials and can cause magnetic contamination.

Figure 16 Brass Bolts for Frame Adjustment

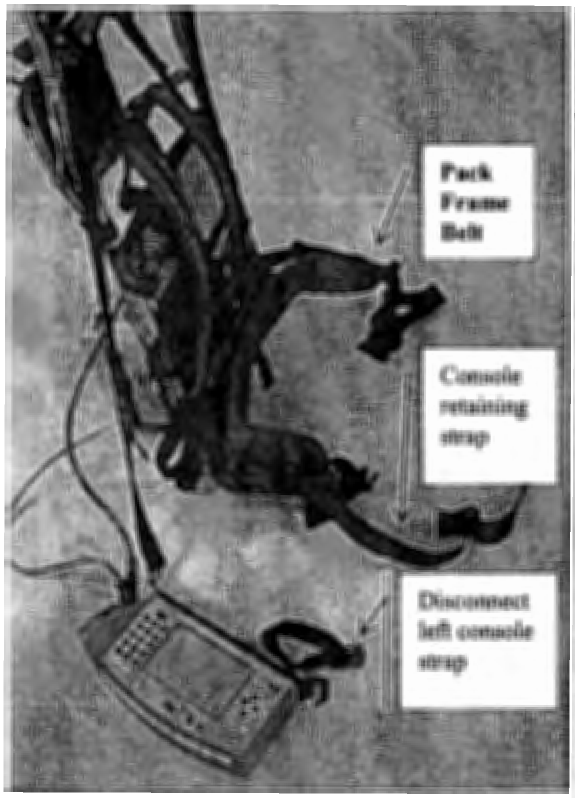


Figure 17 Getting Pack Frame ready for installation

Putting on the Pack Frame

Putting on the pack frame may be most easily performed on a raised surface such as the back of a pickup truck or table. To put on the pack frame, loosen the console retaining strap and remove the G-859 console from the transportation configuration above the battery and swing it out to the side.

Remove the left (facing forward) vertical console retaining strap. Open up both waist belt assemblies. Grasping the G-859 console retaining straps and the right shoulder strap as shown, lift the complete assembly up an onto your right shoulder, making sure the G -859 Console doe not swing into any hard object. See Figures above. Next, work your left arm through the other shoulder harness and seat the pack frame on your shoulders. This may be more easily accomplished with a second person to help make initial adjustments to the fit of the frame.

Figure 18 Wearing the Shoulder Harness

Connect the primary pack frame belt buckle about your hips and tighten the belt. The belt should sit above your hips to support the majority of the pack weight. Identify the secondary Console Waist belt and thread it through the metal tangs on the console attachment bar (see pictures). Attach the console belt buckle and tighten the belt strap as shown in Figure 20. Once the shoulder and waste belts are secure and tightened, attach the second vertical Console support strap and tighten both vertical console straps. This will give vertical support to the console so that it is stable on the front of the body (Figure 21 final assembly)

Finally, connect the front horizontal cross support strap under the clavicles. There are several additional adjustments that can be made to the pack in terms of the waist straps, shoulder straps, console support straps and of course the frame itself. Care must be taken not to use any hardware on the pack other that than which was supplied or that has been screened for magnetic cleanliness.

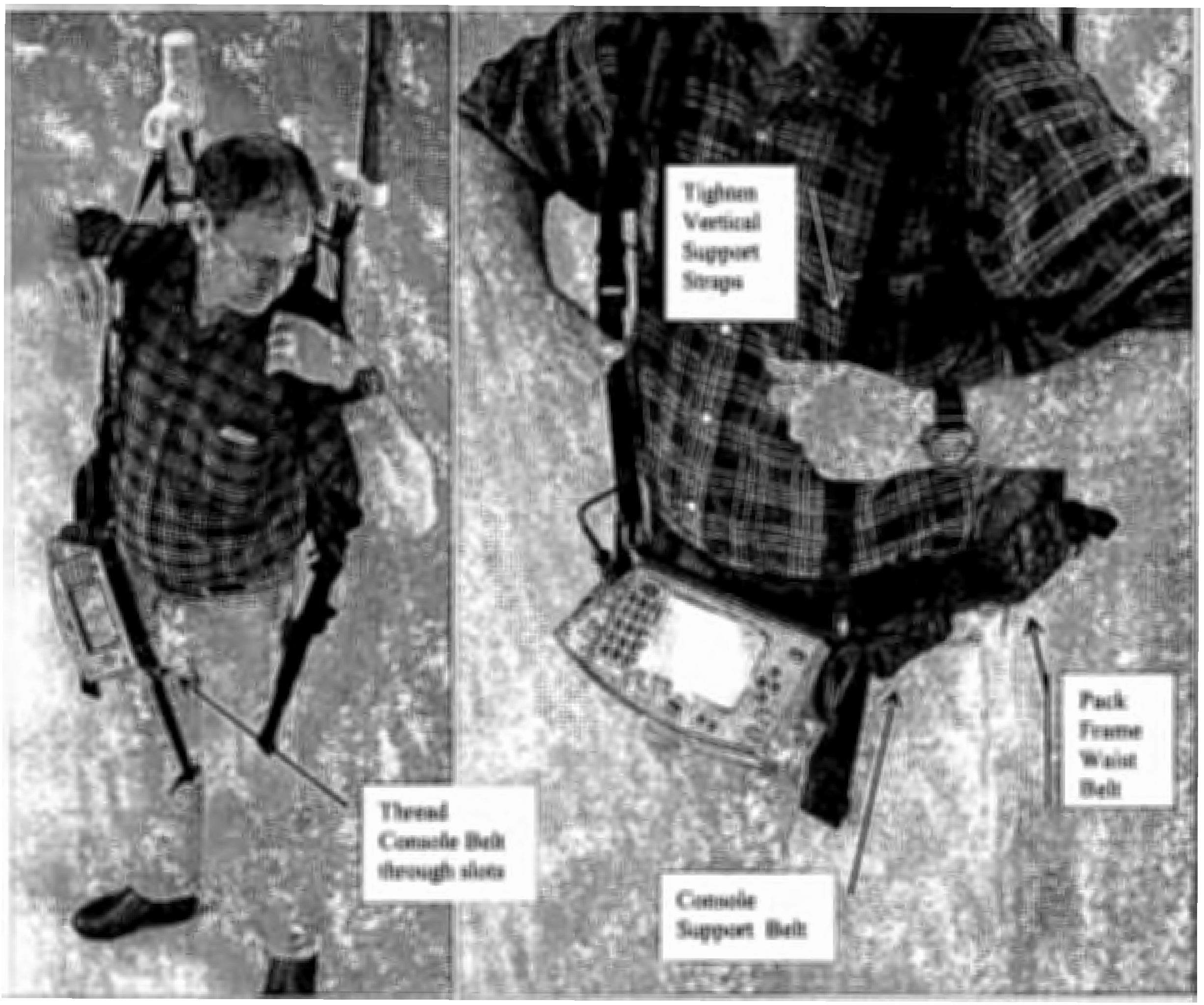


Figure 19 Securing Shoulder straps, console straps and waist belts.

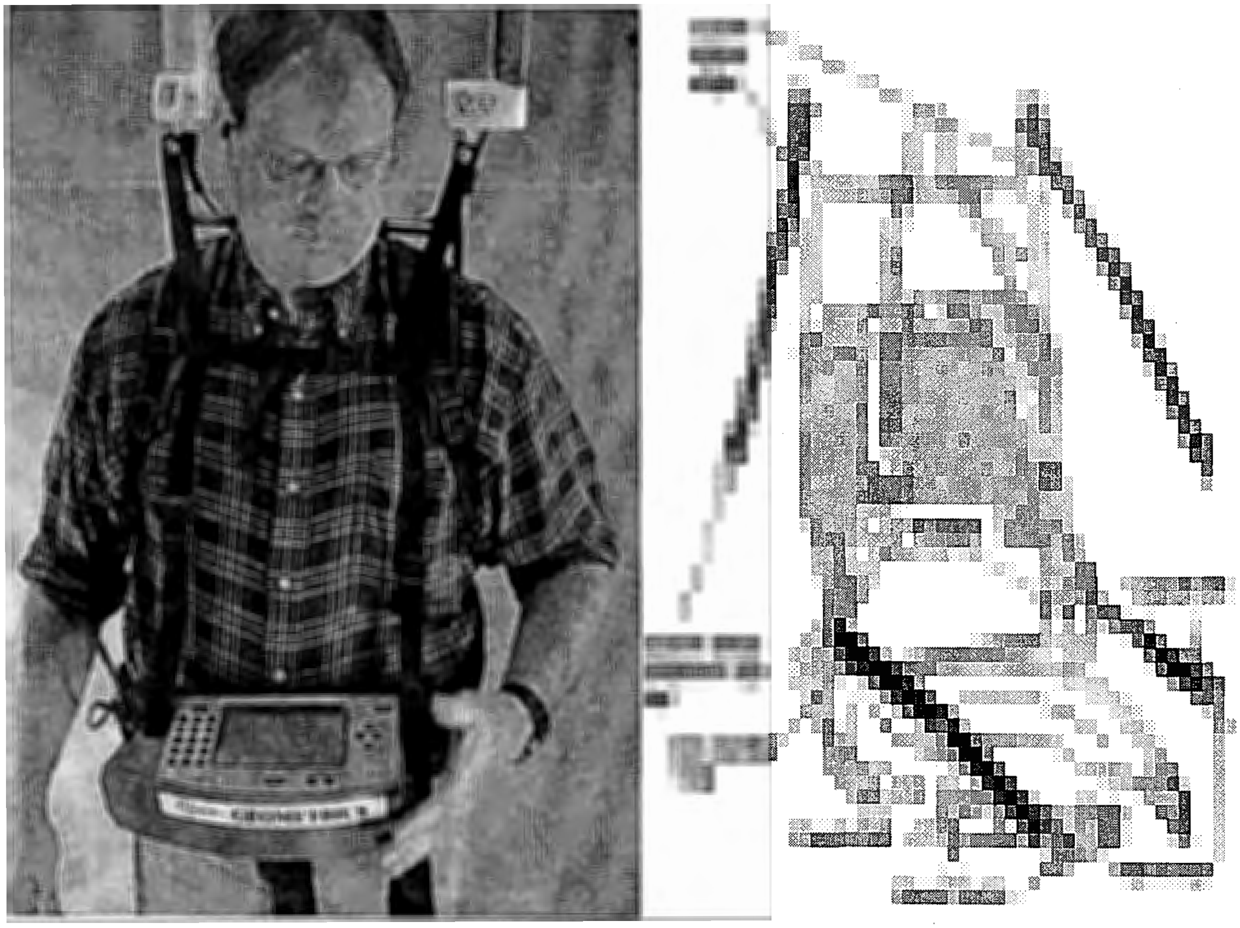


Figure 20 Pack Frame final assembly

Chapter 3: Console and GPS Operation

G-859 Console Operation

The G-859 console is pictured below. The slots in the spreader bar are designed to slip over the console belt. The holes are for attaching the front vertical shoulder straps. The connectors are for the power cable and I/O port (RS-232). The cesium sensor is hard wired into the console.

The upper left connector is the battery connector, the upper right is the serial I/O port, and the lower cable is a non-removable connection for the sensor. Note spreader bar attached to the bottom of the console. This bar attaches the console to the Console Belt and the Console Support Straps.

Plug in the Console and Serial I/O cables in to the console if not already connected and turn on the magnetometer by pressing the power button (latest versions of the console have the power button located in the upper center area of the display panel).

Powering on and off

After charging the battery, connect the console to the battery belt cable. This cable may be tucked into the pouch in the battery belt when not in use.

Press the POWER key to power the unit up. You may need to adjust the display contrast (keys marked LIGHT and DARK) in order to see the display. The menu first shown is the Main Menu:

---G859 MAGNETOMETER V3.04---
Use arrow keys to select desired
function. Confirm with "ENTER"
SEARCH MODE
SIMPLE SURVEY
MAPPED SURVEY
BASE STATION
DATA REVIEW
DATA TRANSFER
SYSTEM SETUP
hh:mm:ss mm/dd/yy Memory free: 99.9%

G-859 Magnetometer menu.

Pressing the POWER key when the Main Menu is displayed will shut the unit off. At other times, the POWER key is ignored

Note: To shut the unit off, press ESC until the MAIN MENU, G-859 MAGNETOMETER menu is shown, then press POWER.

Try not to disconnect the battery cable during use. If the battery cable is disconnected, some of the most recent data may be lost. Every effort has been made to protect your data in this event. However, depending upon what the microprocessor was doing at the time power was interrupted, data corruption may occur.

The unit will power itself off when the batteries reach a low voltage condition. Data back to the last position marker will be lost, however.

Note: The gauges on the left of the display show the battery power and memory left in the G-859. You should keep track of these indicators.

High-pitched sounds coming from the G-859 are normal. Capacitors used on the internal circuit boards exhibit a piezo-electric effect, and create the buzzing noises.

Note: You should allow the sensor to warm up for 5 to 10 minutes before starting the survey, depending upon ambient temperature. During the warm up period, the unit may display an "inoperative sensor" message. If this happens, simply unplug the sensor and plug it back in, or cycle the power of the G-859. See the later section "Warming up the G-859" later in this chapter for the proper procedure.

Using the menus

Selecting fields in a menu

Menu fields are highlighted by pressing the up and down arrow keys. There are 3 types of fields which may be highlighted.

Scroll list.

A scroll list is indicated by the angle brackets, < >, on each side (see the "Baud rate" field in the menu example below). Press the left and right arrow keys to scroll through a list of options. You do not need to press the ENTER key. Simply move out of the field with the up or down arrow key, or press ESC to move up an entire menu level.

Numeric entry field.

A numberic entry field is indicated by square brackets, [ ], on each side (see the "QC warning level" field in the menu example below). Press the DEL key to delete the number that is there, type a new number, and press ENTER. Using the up and down arrow keys to move out of this field without first pressing ENTER will cause the numeric value to return to the last value.

Note: Don't forget to press the ENTER key after entering the desired value. You can also move the cursor within a field by pressing the arrow keys to select and change individual digits.

Function calls.

Function calls are indicated by a text only box, with no angle or square brackets (see the AUDIO, DATE & TIME, and SELF TEST fields in the menu example below). Pressing ENTER in these fields will cause the indicated action to occur.

Menu Example:

```
            ---SYSTEM SETUP MENU---
                     AUDIO
                 DATE & TIME
                COM PORT SETUP
            COM & FIELD NOTE SETUP
              MAGNETOMETER TEST
Real time transfer:      <  DISABLE  >
Use COM1 port as:
          <  ASCII CHARACTER LOGGER  >
```

function call

scroll list

```
              <  CONFIGURE  >


Store serial data in:      < ACQUIRE MODE >
QC warning level:          [ 9.999   ] nT
```

numeric entry

Moving through menus

In this document, "selecting" an item means highlighting it with the arrow keys and pressing ENTER. "Scrolling" to a value refers to highlighting the field item and pressing the left or right arrow keys until the desired value is displayed.

Press the ESC key to back up a menu level.

The first menu displayed on power up is the main menu, shown below.

```
        ---G859 MAGNETOMETER V3.04---

        Use arrow keys to select desired
         function.  Confirm with "ENTER"

                 SEARCH MODE

                SIMPLE SURVEY

                MAPPED SURVEY

                BASE STATION

                 DATA REVIEW

                DATA TRANSFER

                SYSTEM SETUP

   hh:mm:ss  mm/dd/yy  Memory free: 99.9%
```

G-859 Magnetometer menu.

Setting up the G-859

Select the SYSTEM SETUP from the main menu. You will then see the system setup menu.

```
           ---SYSTEM SETUP MENU---
                    AUDIO
                 DATE & TIME
               COM PORT SETUP
           COM & FIELD NOTE SETUP
             MAGNETOMETER TEST
Real time transfer:       <  DISABLE   >
Use COM1 port as:
          <  ASCII CHARACTER LOGGER  >
                <  CONFIGURE  >


Store serial data in:     < ACQUIRE MODE >
```

```
QC warning level:          [ 9.999   ] nT
```

Select DATE AND TIME, showing the date and time menu below.

```
                DATE AND TIME MENU

                      Date
                 Month:    [ 04 ]
                 Day:      [ 24 ]
                 Year:     [ 03 ]


                      Time
                Hour:        [ 12 ]
                Minute:      [ 01 ]
                Second:      [ 12 ]

               SET TO ABOVE VALUES

               12:01:12   04/24/03
```

Date and Time Menu.

Enter the correct values in the numeric entry fields, then highlight SET TO THE ABOVE VALUES, and press ENTER. Remember that when you are using a base station for diurnal correction it is critical that you set the base station clock and this clock to the same time. You do this by setting the time slightly in the future and then pressing the ENTER key just at the times synchronize. Hit ESC three times to return to the Main Menu.

Warming up the G-859

After first powering up the G-859, it may take from 5 to 10 minutes for the unit to warm up and begin operating normally, depending upon the ambient temperature. Here is a recommended procedure for starting and warming up your G-859:

From the G-859 Main Menu:

```
            ---G859 MAGNETOMETER V3.04---

          Use arrow keys to select desired
           function.  Confirm with "ENTER"

                    SEARCH MODE

                   SIMPLE SURVEY

                   MAPPED SURVEY

                   BASE STATION

                    DATA REVIEW

                   DATA TRANSFER

                   SYSTEM SETUP

      12:35:45  04/24/03  Memory free: 99.9%
```

G-859 Magnetometer menu.

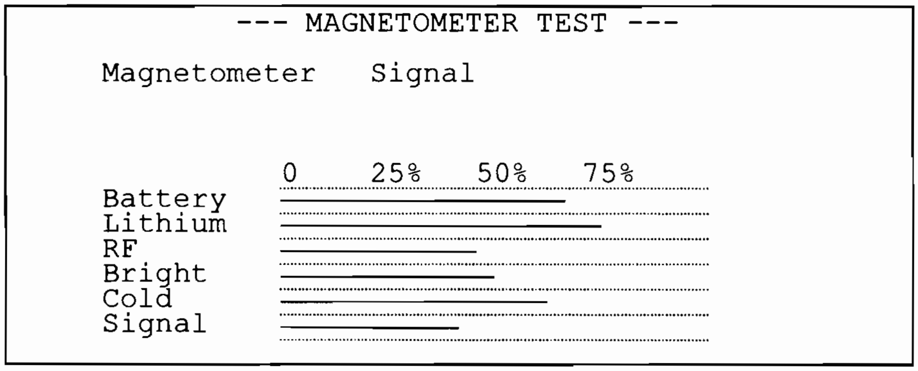
Highlight SYSTEM SETUP and press enter. You should see a display similar to that below:

```
              ---SYSTEM SETUP MENU---
                       AUDIO
                    DATE & TIME
                   COM PORT SETUP
               COM & FIELD NOTE SETUP
                 MAGNETOMETER TEST
Real time transfer:       <  DISABLE  >
Use COM1 port as:
           <  ASCII CHARACTER LOGGER  >
                  <  CONFIGURE  >


Store serial data in:     < ACQUIRE MODE >
QC warning level:         [ 9.999   ] nT
```

System Setup Menu.

Highlight MAGNETOMETER, and press ENTER. You will now see the following display:



Magnetometer Test Display.

The exact display will differ depending upon how many sensors are installed, and how long the unit has warmed up. The unit is warmed up and operating properly when the Bright1 is maintaining a constant reading of 50%.

If no signal is indicated, it usually means that the sensor is oriented in the dead zone, or the field gradient is too high. Try orienting the sensor differently, and move it away from large ferrous metal objects. Typically, in an office or other indoor environment, gradients are too high, and the sensor signal will often not appear. See the section earlier in this chapter for more information on sensor dead zones.

From this menu, you should also check the level of the Lithium battery. If less than 65% (75% is normal) you should have the battery replaced. This should only be necessary every several years.

More information about this display is contained in Chapter 10.

Note: Occasionally, the unit may indicate a bad sensor during the warm-up period. If so, press the ESC key to stop the warning sounds, and then simply unplug the sensor and plug it back in. The sensor will then re-initialize, and should come up to the proper operating point.

You should next select SEARCH MODE from the main menu. (Press ESC 3 times to go back to the MAIN MENU). You can then observe the readings as they occur and play with different sensor orientations. The next chapter explains how to use the Search Mode.

System Setup Menu.

To begin to explore the various modes of operation of the G-859, press the ESC key to return to the G-859 Magnetometer menu and read the chapters that follow.

```
---G859 MAGNETOMETER V3.04---

Use arrow keys to select desired
function.  Confirm with "ENTER"

SEARCH MODE

SIMPLE SURVEY

MAPPED SURVEY

BASE STATION

DATA REVIEW

DATA TRANSFER

SYSTEM SETUP

12:35:45  04/24/03  Memory free: 99.9%
```

G-859 Magnetometer menu.

The G-859 also provides other Self Test functions that may be accessed. From the menu shown above select System Setup .

```
---MAIN MENU V1.12---

Use arrow key to select desired
function.  Confirm with "ENTER"

Select Sensor Type:

MAGNETOMETER

OHMMAPPER

SELF TEST

hh:mm:ss    mm/dd/yy    Memory free 99.9%
```

Main Menu

Use the arrow down key to select SELF TEST and press the ENTER key to see the DIAGNOSTIC MENU.

GPS Operation

The G-859 is supplied with an integrated NovAtel Smart Antenna WAAS/EGNOS enabled GPS. This system operates well in most areas of the world although WAAS is not available in all areas (see below). The Smart Antenna and the G-859 logging console are preprogrammed at the factory for proper operation and no further interaction with the interface is required. In the odd event that the Smart Antenna loses its preprogramming, we provide a programming cable and instructions on how to reprogram the GPS in Section 10 of this manual.

The G-859 uses a metronome beat to help the survey operator keep a steady pace. Should the quality of the GPS fix change, the tone of the Metronome will change to indicate poor GPS data. We will be upgrading this manual in the near future with additional information on this feature.

What is WAAS? Basically, it is a system of satellites and ground stations that provide GPS signal corrections, giving better position accuracy than standard GPS. On average the position accuracy is increased up to factor of five times. A WAAS-capable receiver can give a position accuracy of better than three meters 95 percent of the time. There are no service fees to use the WAAS service.

Currently, WAAS satellite coverage is only available in North America. There are no ground reference stations in South America, so even though GPS users there can receive WAAS, the signal has not been corrected and thus would not improve the accuracy of their unit. For some users in the U.S., the position of the satellites over the equator makes it difficult to receive the signals when trees or mountains obstruct the view of the horizon. WAAS signal reception is ideal for open land and marine applications. WAAS provides extended coverage both inland and offshore compared to the land-based DGPS (differential GPS) system. Another benefit of WAAS is that it does not require additional receiving equipment, while DGPS does.

Other governments are developing similar satellite-based differential systems. In Asia, it's the Japanese Multi-Functional Satellite Augmentation System (MSAS), while Europe has the Euro Geostationary Navigation Overlay Service (EGNOS). Eventually, GPS users around the world will have access to precise position data using these and other compatible systems.

Self Test

Selecting SELF TEST from the Main Menu will display the following menu:

```
DIAGNOSTIC MENU

KEYPAD
SOUND
DISPLAY
REAL TIME CLOCK
MEMORY
SERIAL PORT
PICKLE SWITCH
!!! FORMAT MEMORY !!!
```

Keypad
This will bring up a menu for testing the keypad.

Sound
This will emit a continuous sound at maximum volume for you to test your hearing.

Display
Checks to see if the graphics mode of the display is working.

Real Time Clock
Checks the on-board real-time clock.

Memory
Checks the system memory. DO NOT DISCONNECT THE BATTERY DURING THIS TEST. Doing this will result in loss of all data stored in the instrument.

Serial Port
Checks the serial port. You must attach a loop-back cable, available from computer stores, in order to perform this test.

Pickle Switch
Tests the optional external switch.

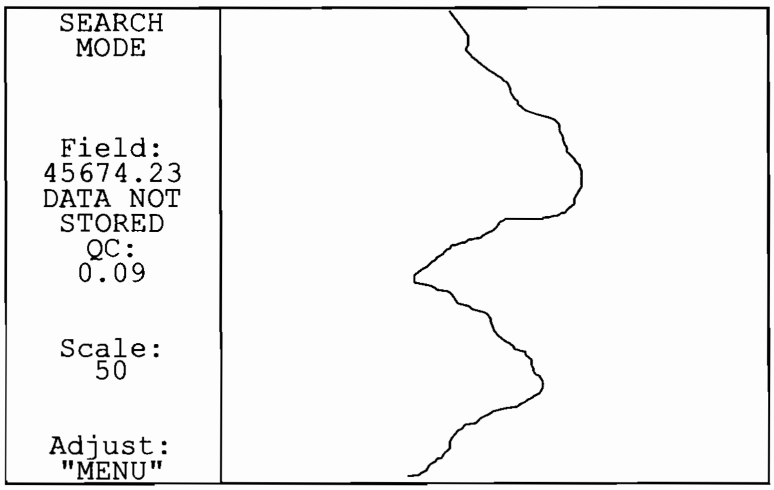
Format Memory
Erases the entire data memory of the G-859. All data in all files will be lost. If the system hangs up at some point, you may need to do this after power up to get the unit to behave properly.

Chapter 4: Search Mode

Search Mode

In search mode, the magnetometer operates normally, displaying data and the woowee audio tones, but data is not stored in memory. This is useful for manually identifying anomaly locations, much as with a metal detector. It is also useful for checking for proper sensor operation and ambient magnetic noise.

Select SEARCH MODE from the main menu. You should see a display similar to that below:



Example of Search Mode Display

Note: Data is not stored in Search Mode. This is indicated on the display, so you do not confuse it with Simple Survey.

Search Mode Adjust Menu

Pressing the MENU key will bring up the Search Mode Adjust Menu. This allows you to adjust the display and audible tones:

SEARCH MODE	Master volume: < 4 >
Field: 49953.1 DATA NOT STORED QC: 0.33	Woowee: Volume: < 4 > Sensitivity: < 4 > Hz/nT QC warning Volume: < 4 > Level: [9.999] nT
Scale: 50	Full scale: < 50 > nT Rdngs/screen: < 25 >
ADJUST: "MENU"	Cycle Time [0.2] s CENTER TRACE

Search Mode Adjust Menu.

Master Volume
Adjusts the over-all volume. 1 is softest, 9 loudest.

Woowee Volume
1 is softest, 9 loudest

Woowee Sensitivity
Adjusts the amount the pitch of the woowee changes with varying field readings.

QC warning volume
1 is softest, 9 loudest

QC warning level
Sets the threshold for the QC warning to be emitted. If the QC exceeds this threshold, the warning is sounded.

Full Scale
Sets the trace width full-scale of the display.

Readings per screen
Sets the vertical scale of the trace display. Higher values means the trace moves more slowly down the screen.

CENTER TRACE
Centers the trace in the sweep display.

Pop up Menus

While in Search Mode (and the other modes as well), there are two quick pop up menus that are accessible:

Audio Key

Pressing the AUDIO key will bring up an audio adjust indicator. Then the up- and down-arrow keys will adjust the volume, while the right- and left-arrows will adjust the pitch of the woowee. The audio adjust indicator will disappear after a few seconds.

Scale Key

Pressing the SCALE key will bring up an scale adjust indicator. Then the up- and down-arrow keys will adjust the speed of the sweep (readings shown per page), while the right- and left-arrows will adjust the full scale (in nT). The scale adjust indicator will disappear after a few seconds.

Chapter 5: Simple Survey Mode

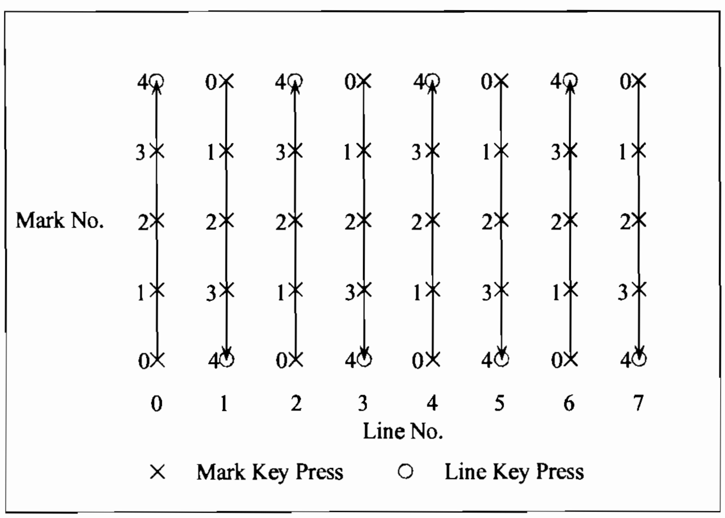
Simple Survey

Once the unit is reading properly in Search Mode, you are ready to begin your survey. If you are unfamiliar with magnetic surveys, please read Appendix 1 and the *Applications Manual for Portable Magnetometers*, shipped with your G-859.

In simple survey mode, the unit keeps track of MARK and END LINE key presses in order to locate the position of the sensor readings. Later, after downloading the data into the PC, you will use the MagMap2000 program to attach an x and y coordinate to each reading.

Survey Overview

Typically, a survey is performed by walking up and down the survey area, surveying a series of lines, as shown below.



Simple Survey Overview

It is most convenient to survey lines walking in both directions, as shown, rather than walking back to the bottom of the map, always surveying up (either method maybe used, however). You will start at the lower left corner of the map, and walk up line 0. pressing the MARK key at each 'X'. At the end of line, press the END LINE key. You will then walk d.own line 1, and so on until the survey is finished.

Note: The line and mark numbers begin at zero. This is the most common convention, and the one adopted in the G-859. It is important to remember this, as it is sometimes easy to get confused. The survey shown above has a total of 8 lines, starting with number 0.

The MARK points are numbered sequentially, even in the case of a bi-directional survey, as shown in the previous figure.

MARK key presses are numbered starting from 0 at the beginning of the line. This is true whether you survey lines walking in both directions or not. The MagMap2000 software will sort out the line direction on the PC.

If a survey is expected to last several hours or more, it is strongly recommended that you set up a second magnetometer as a base station to be used to correct for the diurnal variations in the Earth's magnetic field.

Setting up a Simple Survey

Select simple survey from the main menu, bringing up the simple survey main menu.

```
         --- SIMPLE SURVEY MAIN MENU ---
    File < 1 >      MAG     EMPTY



        Survey Mode:        < CONTINUOUS >

         Cycle Time:         [ 0.2      ] s

          Next Line:           0
          Next Mark:           0

                  START NEW SURVEY

     17:52:23  04/24/03  Memory Free  99.9%
```

Simple Survey Main Menu.

If someone else has already stored some surveys, the menu may not say empty. Highlight the file number, and press the left or right arrow keys until an empty file is displayed. If all 5 files are used, you will need to erase one of them. Please check with whomever has made these surveys to make sure they have downloaded the data. Files may be erased through the DATA TRANSFER section of the Main Menu. See Data Transfer, later in this chapter.

File

File numbers from 1 through 5 may be selected. You may start a new survey from any empty file number, and may continue any Simple Survey file.

Survey Mode:

Set to CONTINUOUS for continuous data acquisition at the rate given by the cycle time, set in the field below. In discrete mode, the unit will take and store a reading at each END LINE or MARK key press.

Cycle Time

This field has two functions. In continuous mode, it sets the rate at which readings are stored. This number also sets the measurement interval. Increasing this interval will increase the resolution, up to the maximum resolution which occurs at 1.5 seconds. Numbers higher than that will increase the spacing between readings, but will not affect the resolution.

In discrete mode, this number sets the measurement interval only. Increasing this number up to 1.5 seconds will increase the resolution. Again, beyond that, the resolution will not increase.

Next Line

Next Mark

Where the unit expects you to start or continue the survey.

Note: Every new survey will begin at Line=0, Mark=0. After downloading the data into the PC, you will use the MagMap2000 program to specify the actual starting coordinates.

If you wish to continue a previous data set, scroll the data set number to the desired set, then select CONTINUE SURVEY. Data sets for mapped surveys or base station surveys will be shown as the data set number is scrolled. However, from this menu you may not select CONTINUE SURVEY for anything other than simple surveys.

Acquiring Data

Once START NEW SURVEY or CONTINUE SURVEY has been selected, the display will change to the acquisition display.

```
   SIMPLE
   SURVEY

   Field:
  49876.48
  !READY!
    QC:
   0.06

   Scale:
     50

RS-232 in:

Line:
 0
Mark:
 0
```

Acquisition Display.

The items shown on the acquisition display are as follows:

Field:
Displays the magnetic field reading.

READY
Indicates that the instrument is ready to acquire data. Data is not currently being acquired, however.

QC:
Displays a quality check indication. This value grows for rapidly varying fields. If the value exceeds a threshold (set in the system setup menu or the adjust menu) a warning sound will be heard.

Scale
Displays the full-scale width of the sweep trace on the right hand side of the display, in nT.

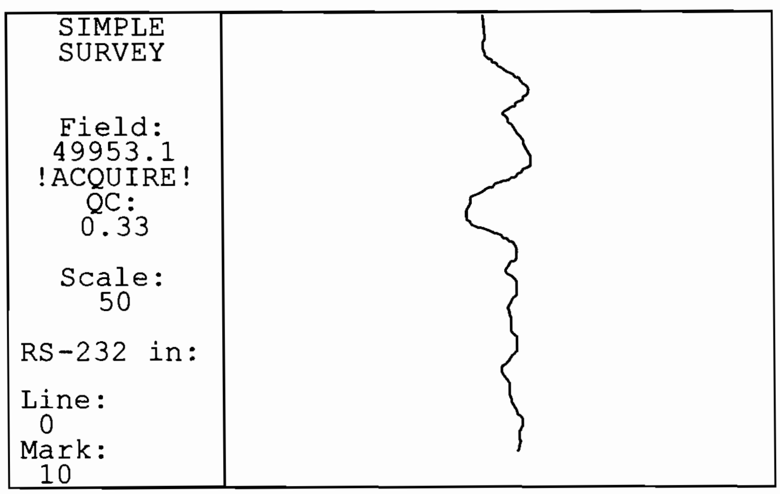
Line
Indicates the line number at which your next END LINE or MARK key press is expected.

Mark
Indicates the mark number at which your next MARK or END LINE key press is expected.

Note: The line and mark number displayed is always the location of the *next* MARK or END LINE key press.

The unit will not be taking data yet. To start data taking, go to the starting or continuing point (indicated on the display) press the MARK key, and start walking. If you have established way points along the profile, press the MARK key at each way point. Press END LINE when you reach the end of a survey line. Press PAUSE if you want to stop recording, and PAUSE again to resume recording (the PAUSE key is effective only in continuous mode). The data display will indicate the reading with a trace display.

Note: The MARK key performs two operations. It starts the storage of data (at the beginning of a line) and logs positions into memory.



Acquisition Display with Reading Trace.

When you reach the end of each line, press the END LINE key. Upon this action, the unit will stop logging data and display a summary of the previous line:

```
YOU HAVE JUST REACHED THE END OF LINE.
        YOU ARE CURRENTLY AT:
              LINE: 0
```

MARK: 10

PRESS ANY KEY TO CLEAR THIS MESSAGE

THEN PRESS "MARK" TO START NEXT LINE

OR

PRESS "MENU" AND SELECT
"EDIT LINE AND MARK"
FOR EDITING

To start the next line, you must first press any key to clear this dialog box, then press MARK as you start walking up the next line. We encourage you to look at this line summary between lines, to make sure you are where the unit thinks you are, and the last line has the right number of mark key presses. If there is a problem at this point, you may edit the most recently taken data. You are not able to edit any except the most recently acquired data.

Note: Don't forget the key press necessary to clear the dialog box. The END LINE key is handy for this since it was the last key pressed. If you forget to clear the dialog box, the next MARK key press will not start data acquisition (it will only clear the dialog box).

Adjust Menu

Pressing the MENU key from the Acquisition Display will bring up the adjust menu. This allows you to adjust the display and audible tones, and to enter the data editing menu.

SIMPLE SURVEY	
	Master volume: < 4 >
	Woowee:
	Volume: < 4 >
Field:	Sensitivity: < 4 > Hz/nT
49953.1	
!ACQUIRE!	QC warning
QC:	Volume: < 4 >
0.33	Level: [9.999] nT
Scale:	Full scale: < 50 > nT
50	
	Rdngs/screen: < 25 >
RS-232 in:	
	EDIT LINE AND MARK
Line:	
0	CENTER TRACE
Mark:	
0	

Simple Survey Adjust Menu.

Master Volume

Adjusts the over-all volume. 1 is softest, 9 loudest.

Woowee Volume

1 is softest, 9 loudest

Woowee Sensitivity

Adjusts the amount the pitch of the woowee changes with varying field readings.

QC warning volume

1 is softest, 9 loudest

QC warning level

Sets the threshold for the QC warning to be emitted. If the QC exceeds this threshold, the warning is sounded.

Full Scale

Sets the trace width full-scale of the display.

Readings per screen

Sets the vertical scale of the trace display. Higher values means the trace moves more slowly down the screen.

EDIT LINE AND MARK

Opens the data editing menu. See detail below.

CENTER TRACE

Centers the trace in the sweep display.

Pop up Menus

From the acquisition display, there are two quick pop up menus that are accessible:

Audio Key

Pressing the audio key will bring up an audio adjust indicator. Then the up and down keys will adjust the volume, while the right and left arrows will adjust the pitch of the woowee. The audio adjust indicator will disappear after a few seconds.

Scale Key

Pressing the scale key will bring up an scale adjust indicator. Then the up and down keys will adjust the speed of the sweep (readings shown per page), while the right and left arrows will adjust the full scale (in nT). The scale adjust indicator will disappear after a few seconds.

Pausing

Pressing the PAUSE key while acquiring data will temporarily stop data acquisition. At this point, you may do any of the following:

Press PAUSE. This will re-start the acquisition process.

Press MARK. This will enter the current position. Do this only if you are currently at one of your way points. Only one MARK key press is allowed. The instrument will stay in pause mode.

Press END LINE. This will enter the END LINE position. Do this only if you are at the end of the line. The instrument will switch out of pause mode, and into the normal between-line state. Next, press the MARK key to start taking data.

Editing Data

Selecting EDIT LINE AND MARK from the adjust menu (above) will show the edit menu.

```
SIMPLE SURVEY EDIT MENU

You are currently going to:
        Line:    4
        Mark:    1


GO BACK TO LAST POSITION:
        Line:    4
        Mark:    0

DELETE LINE:
 Line:   4


RETURN TO SURVEY
```

Simple Survey Edit Menu.

From this menu, you may delete the most recently acquired data.
The meanings of the menu items are:

GO BACK TO LAST POSITION

Selecting this will delete data to the last MARK or END LINE key press.

DELETE LINE

Selecting this will delete the most recent line. If you are in the middle of a line, the current line will be deleted.

Examples - Recovering From Common Mistakes:

Mistakenly pressing MARK instead of END LINE at the end of a line.

This is a fairly common occurrence, and easily fixed. First, press PAUSE to halt the data acquisition. Then press ESC to close the dialog box. Press MENU, then highlight EDIT LINE AND MARK and press ENTER to bring up the Edit Menu, shown above. Highlight GO BACK TO LAST POSITION and press ENTER. Next, press ESC twice, to show the Acquisition Display. Then press END LINE. You have now corrected your mistake.

Sometimes, after pressing the MARK key at the end of a line, you might press the END LINE key instead of PAUSE, as mentioned above. In this case, from the Edit menu you should highlight GO BACK TO LAST POSITION and press ENTER *twice*. The first press takes you back to the position entered by the END LINE key press (which is one mark spacing past where you want it to be). The second press takes you back to where you actually want the end of line to be. Then, you press ESC twices, and press END LINE.

Mistakenly pressing END LINE instead of MARK in the middle of a line.

After pressing END LINE in the middle of a line, press ESC to clear the dialog box. Then, press MENU, highlight EDIT LINE AND MARK and press ENTER. Next, highlight GO BACK TO LAST POSITION and press ENTER. Press ESC twice to bring up the Acquisition Display.

You are now ready to continue the line where you were when you originally pressed the END LINE key. Position the sensor at the proper location, press MARK, and start walking. You are now taking data.

Realizing the data for your current line is erroneous.

Another common reason for editing data is if you realize a line has incorrect data, often either due to missing a MARK key press at a fiducial point, or walking off course. If this occurs, simply press the END LINE key, enter the edit menu, highlight DELETE LINE and press ENTER. Then select RETURN TO SURVEY (or press ESC), walk back to the beginning of the line, make sure the next line number displayed is correct, press the MARK key and begin the line over again.

Note: From the edit menu, you may delete as many lines or segments as you wish, all the way back to the beginning of the survey.

Summary

Data editing in simple survey is somewhat like pressing backspace on a computer. You can delete data and positions going backward from the most recent key presses. Note that this is the only way to alter the counting of marks and lines.

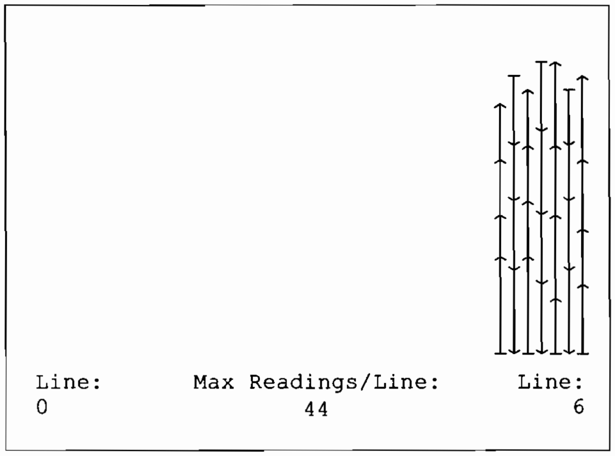
After making data edits, it is very important to make sure the current line and mark number are where you intend to take data. It is strongly recommended that you look at the Map display after editing data. See the next section on viewing data.

Viewing Data

Pressing the MAP or CHART key from the Acquisition Display will bring up a representation of the data acquired. These keys may be pressed at any time. The unit will pause while you look at the display.

Map Display

On the map display, each mark is represented by an arrow in the default direction. The distance between marks is proportional to the number of readings taken. Thus, if you are doing a bi-directional survey, and are walking at a steady pace, this display will correspond to a physical map. Otherwise, it gives an indication of the number of marks in each line and the number of readings taken between marks. The map display, after 7 lines of data have been taken, is shown below:



Map Display in Simple Survey Mode

Data is shifted all the way to the right, with the oldest data shown on the left. The number at the lower left indicates the number of the left-most line, while the right hand number indicates the right-most line on the display. The arrow keys may be used to scroll the display, if necessary.

Pressing ESC will exit the map display.

Chart Display

You may review the data readings as profiles by pressing the CHART key. You may scroll both the map and charts by hitting the left and right arrow keys. If you were logging data when you pressed the MAP or CHART keys, the unit will enter the pause mode while it is displaying the map or profiles. To restart data acquisition, press ESC, then PAUSE. The chart display is shown below:

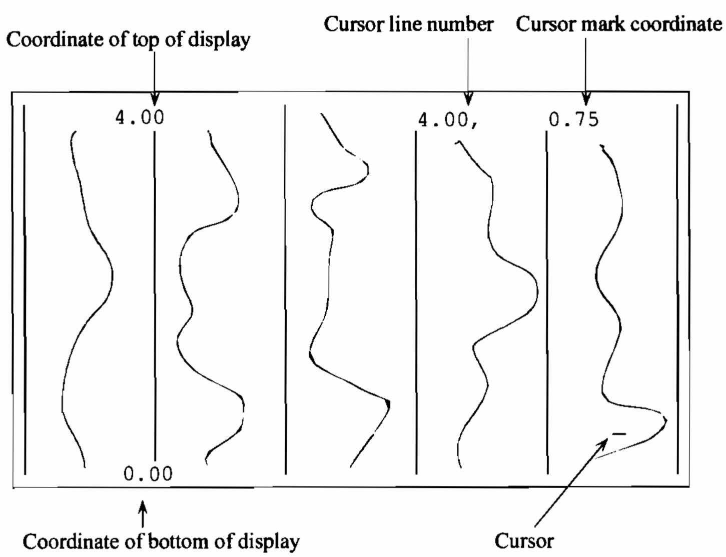


Chart Display in Simple Survey.

On the chart, coordinates are in units of marks. For example, a y-value of 3.5 indicates half way in between mark 3 and mark 4.

Chapter 6: Mapped Survey.

Introduction

Mapped survey allows you to better specify and visualize the survey area than simple survey, and to move around within the area in a non-continuous fashion. Using the arrow keys, you may position the cursor anywhere within the map, and acquire data. Default cursor movements are programmed into the unit, so if you follow a normal serpentine path across the survey area, you may simply press the MARK and END LINE keys as if you were doing a simple survey.

Mapped mode allows you to

- Define a rectangular survey area with pre-defined fiducial, or mark, points on a regular grid.
- Take data in a uni-directional, or bi-directional default pattern.
- Move to any arbitrary position within the survey area to take data.
- Leave gaps in the survey where positions are inaccessible.
- Observe on-screen where all data points have been logged.

Setting up the survey

From the main menu, select MAPPED SURVEY.

```
          --- Mapped Survey Main Menu ---

              Data Set Number    < 2 >
     MAG   EMPTY

             Survey Mode   < CONTINUOUS >
          With    [ 0.2     ]  S cycle time

                     DEFINE MAP




        19:07:13  04/24/03  Memory Free  93.3%
```

Mapped Survey Main Menu

To start a new data set, press the right or left arrow keys until an empty data set is indicated. The Survey Mode may be set to continuous or discrete. In discrete mode, a reading will be taken only upon the operator pressing the MARK or END LINE keys. In continuous mode, readings are taken at intervals specified by the cycle time. The cycle time may be set from 0.2 to 6553.4 seconds in 0.1 second increments. Adjust the parameters shown, if necessary, then select DEFINE MAP. This brings up the set up display menu.

Defining the Survey Area

```
          ---  SET UP DISPLAY ---

      This menu sets up how the X and Y
        axes are displayed on the map.

         < BIDIRECTIONAL   > Survey

Lower left corner of display:
     X: [ 0.00        ]    Y: [ 0.00        ]

Upper right corner of display:
     X: [ 100.00      ]    Y: [ 100.00      ]

          Survey parallel to < Y > axis

          Line Spacing:       [ 2.00   ]

          Mark Spacing:       [ 20.00  ]

               DONE ENTERING INFO
```

Set Up Display Menu

The actions of the various fields areas follows:

Bi-directional or uni-directional survey

This field describes whether you will take data walking both up and down lines or walking up the lines only.

Lower left corner

Upper right corner

Here, you must describe the coordinates of the survey area by entering the lower left and upper right extents of the displayed area. If the area is not a rectangular shape, define a bounding rectangle containing the survey site. You may use any units you like.

There are several things you must keep in mind when deciding how to define the survey, and how you will be walking to cover the area. First of all, survey lines are assumed to be shown vertically on the display. This makes it easier to visualize where you are when you are standing at the beginning of a survey line looking towards the end of the line.

Secondly, the unit assumes that you will be surveying lines from left to right across the display. In other words, when the END LINE key is pressed the cursor will move to the next line to the right on the display.

The map height must be an integral number of mark spacings. During the survey, you may manually enter positions at ends of lines which do not reach to the next fiducial mark. See the section "Manually Entering a Position," later in this chapter.

Note: Remember that you are defining the way the coordinates are viewed on the display of the G-859. See the later section "Defining a Physical Area" for more details on how to define your survey.

Survey parallel to X or Y axis

This action defines which axis you want displayed vertically on the screen. This is the axis your lines will be parallel to.

Line spacing

Mark spacing

These items define the distance between lines or marks.

Enter the desired parameters in the set up display menu, then select DONE ENTERING INFO, or press ESC.

Note: If the unit beeps and displays a warning dialog box, you have entered inconsistent information. Usually, this means that the chosen survey direction (x- or y-axis) is not vertical on the display screen. Either change the survey direction or the lower left and/or upper right values for the display. See Defining a Physical Area for more information.

After the G-859 accepts the values you have entered, the mapped survey main menu will reappear, with some new options:

```
             --- MAPPED SURVEY MAIN MENU ---

                 Data Set Number     < 2 >
MAG     EMPTY

     Survey Mode  continuous
     With    [ 0.2     ]  S cycle time

                        DEFINE MAP


                       BEGIN SURVEY
     AT X [0.00          ] Y [ 0.00        ]
                     Going <  UP   >



      19:07:13  04/24/03  Memory Free  93.3%
```

Now you can manually adjust the starting point, if desired. The default starting point will be the lower left corner, and the unit will assume you will be initially walking up the display. You may adjust the starting point and direction, if desired. Then select BEGIN SURVEY.

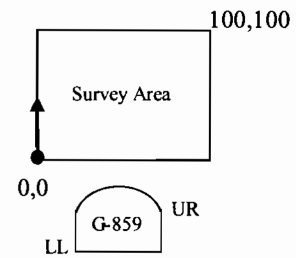
Continuing a previous mapped survey is done in a similar way. Scroll to the desired data set number, then select CONTINUE SURVEY.

Note: You may redefine the map region for a survey that has data in it. This is done simply by selecting DEFINE MAP from the main map menu, and modifying the data. This allows an enormous amount of flexibility in taking a survey. Please see the section "Multiple Grid Surveys" below.

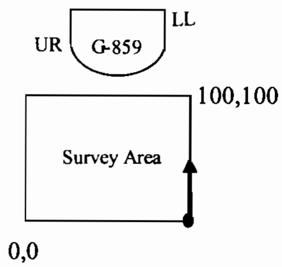
The following provided examples of how to set up the G-859 for varios surveys.

MINING MAG MAPPED SURVEY MODE - PARALLES TO Y AXIS

All coordinates are defined as (x,y)



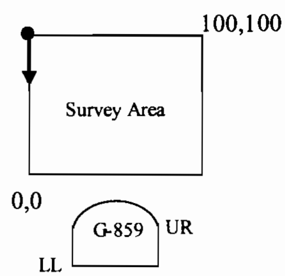
LL(0,0) Y axis
UR(100,100) Start UP at (0,0)



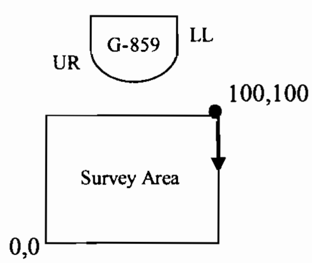
LL(100,100) Y axis
UR(0,0) Start DOWN at
(100,0)

NOTE: Though you are surveying the area from right to left, the map appears left to right

---



LL(0,0) Y axis
UR(100,100) Start DOWN at
(0,100)



LL(100,100) Y axis
UR(0,0) Start UP at
(100,100)

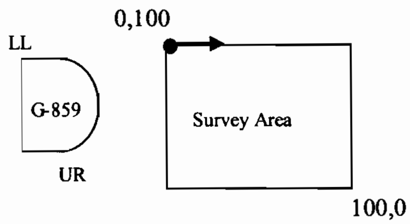
NOTES: **UR** is Upper Right, **LL** is Lower Left.
All surveys assume 100 by 100 units. Any rectangular dimension is acceptable.
●→ Represents the start and direction for the first line.

Represents the G-859 Console orientation.

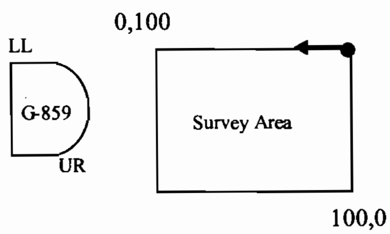
All above Mapped surveys will import into MagMap2000 2000 and result in correctly located data.

MINING MAG MAPPED SURVEY MODE - PARALLEL TO X AXIS

All coordinates are defined as (x,y)

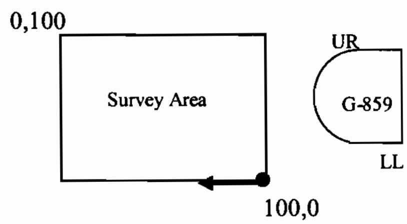


LL(0,100) X axis
UR(100,0) Start UP at (0,100)

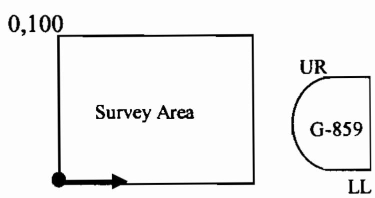


LL(0,100) X axis
UR(100,0) Start DOWN at (100,100)
NOT VALID FOR UNIDIRECTIONAL

NOTE: Though you are surveying the area from right to left, the map appears left to right on the display.

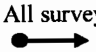


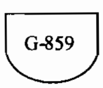
LL(100,0) X axis
UR(0,100) Start UP at (100,0)



LL(100,0) X axis
UR(0,100) Start DOWN at (0,0)
NOT VALID FOR UNIDIRECTIONAL

NOTES: **UR** is Upper Right, **LL** is Lower Left.
All surveys assume 100 by 100 units. Any rectangular dimension is acceptable.

 Represents the start and direction for the first line.



Represents the G-859 Console orientation

All above Mapped surveys will import into MagMap2000 200 and result in correctly located data.

Acquiring Data

Either beginning a new survey or continuing an old one will bring up the map acquisition display.

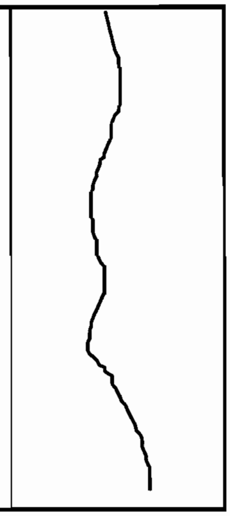
```
Next Position
  Line       1   Mark       10
        20.00             200.0


Last Position
  Line       1   Mark        9
        20.00            180.00


   Going DOWN

 RS-232 in:

 PUSH MARK TO START
```



Data Display Screen

Just as in simple survey, data acquisition is started upon the operator pressing the MARK key. Acquisition will stop when the END LINE key is pressed. Position events will be stored when the MARK key is pressed during data acquisition. The PAUSE key will temporarily halt acquisition; pressing it a second time will re-start acquisition.

The top line of the display shows the position where you should next press the MARK or END LINE key. This should, of course, be the position you are walking toward. Below this line is shown the position of the last position event stored.

See the Advanced Features section later in this chapter for more information on specifying your position.

Note: From this display, you may press the MENU key to bring up the acquire menu, the MAP key to bring up the map display , or the CHART key to bring up the data review menu. These functions are described next.

Acquire Menu

Pressing the MENU key will bring up the acquire menu.

```
              --- ACQUIRE MENU  ---


              Next X =   24.00
              Next Y = [ 100.00     ]
          Current Direction  < DOWN >

           Full scale:    < 50   > nT

        <   25   > Readings per screen

               EDIT LINE AND MARK

              Cycle Time  [ 0.2   ] S
```

Next X

Next Y

You may change position along the line you are on. Depending on the direction of your survey, you will be allowed to enter a number into one of these two fields. This is very useful when your path is blocked. See the later section "Advanced Features" for more information on using this feature.

If you are between lines, you will be allowed to adjust both of these numbers. You cannot, however, enter a line position which isn't on the regular grid. To do that, you must re-define the grid. See the section on Multi-Grid Surveys.

Note: You may also change the next position by pressing the arrow keys directly from the acquisition display after an END LINE key press.

Current Direction

You may toggle between up and down.

Full scale

The scale width of the sweep display, in nT.

Readings per screen

The vertical scale, or sweep rate on the display.

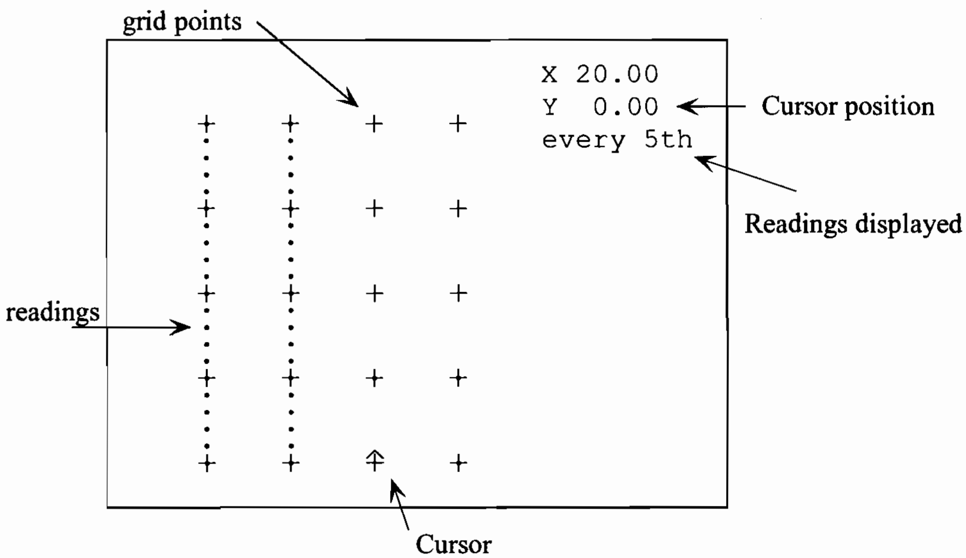
EDIT LINE AND MARK

Brings up the editing menu, see below.

Pressing ESC will return the unit to the acquisition display.

Displaying the Map

The map is displayed by pressing the MAP (.) key from the data display screen:



Map Display. Map is shown after two lines of data have been taken.

Note: To restart data acquisition, first press ESC to clear the map. Then press the MARK key.

Some care must be taken in orienting the map display with the real world. On the display, the line direction is always up and down. The survey is also assumed to start at the left side of the display. Each time the MARK or END LINE key is pressed, the position is automatically updated on the map, according to whether you have selected a unidirectional or bi-directional survey. The position indicated is where the unit thinks you should be walking toward (where you will next press the END LINE or MARK keys). You may change this to any other fiducial mark by pressing the cursor keys to manually change position.

The baseline of the survey is displayed along the bottom. This is assumed to be a straight line. The edge opposite the baseline may be a more arbitrary shape within the rectangle you specified. This is done by manually entering and changing positions when you are starting or stopping a line at a position other than the back edge of the rectangular map display.

Note: After positioning the cursor, you must make sure it is pointing in the direction you want to go. Pressing "2" will point the cursor upward, and "8" will point the cursor down.

Map Menu

From the map, the MENU key brings up the Mapped Survey Map Menu:

```
--- MAPPED SURVEY MAP MENU

Move to position
     [  20.00      ] [  100.00     ]

Show <   EVERY    >  data point
```

Mapped Survey Map Menu

Move to position
This allows you to position the cursor by entering a position.

Show data point
It also allows you to reduce the number of data points plotted, to speed up the drawing process.

Pressing ESC will return the unit to the map display.

Viewing Data

Data profiles may be reviewed by pressing the CHART (-) key. The arrow keys will scroll through the data. Pressing the SCALE or MENU keys will allow you to adjust the scale.

Each line is plotted in its own lane. Values "wrap around" inside the lane. The scale may be set by pressing the scale key, or by pressing menu and bringing up the Chart adjust menu.

The chart display is shown below.

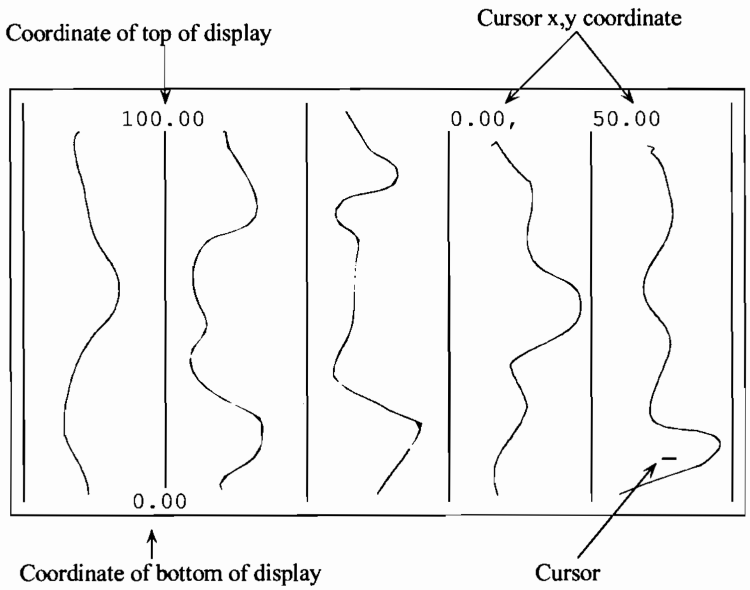


Chart Display for Mapped Survey.

Pressing the MENU key will bring up the data review menu:

```
                --- DATA REVIEW MENU ---


    Move to position:
                X = [  80.00     ]
                Y = [ 100.00     ]


          Full scale:  <  2   >  nT


        Zoom to show  <   ALL  > of line
```

Move to position

This will jump the cursor to a particular position, and scroll the data to that point. This is useful to rapidly page back to a particular point, without having to scroll through the entire file.

Full scale:
Set the full scale of each lane, in nT.

Zoom to show portion of line
Sets the vertical scale of the display.

Editing Data

Introduction
Data editing may be done in two ways. The most-recently taken data may be deleted and retaken, or you may simply retake data from anywhere within the survey. If data has been taken from overlapping locations, the MagMap2000 software will allow you to select which set of data you want. Doing the editing on the PC, however, is an involved process. It is much easier to delete data and retake it on the spot.

Data editing in Mapped Survey is somewhat different from Simple Survey. In Mapped Survey, you have much more flexibility in positioning the cursor where you want when you are finished editing. Thus, if the default position of the cursor is not what you want, you may simply use the map and cursor movement functions to reposition it. You do not need to press the END LINE key, for example, to indicate an end of line. Simply reposition the cursor at the next line.

Also, remember to use the map make sure you deleted the data you intended to. To move from the editing menu to the map, press ESC twice, then MAP. To go back to the editing menu from the map, press ESC, MENU, then highlight EDIT LINE AND MARK (it probably will be highlighted already) and press ENTER.

Procedures
The data editing menu is reached from the acquire adjust menu. From the Acquisition Display, press MENU, then select EDIT LINE AND MARK.

```
          --- MAPPED SURVEY EDIT MENU ---

                  Last position:
                    0.00        20.0


                  Prior position:
                    0.00,       0.00


        DELETE DATA BETWEEN THESE POSITIONS

                  DELETE LINE

                RETURN TO SURVEY
```

Mapped Survey Edit Menu

DELETE DATA BETWEEN THESE POSITIONS

This function deletes data back to the prior mark. You will then be positioned at that previous mark.

DELETE LINE

This will delete an entire line of data. It will delete the line you are currently on, or, if the current line has no data in it, it will delete the previous line.

Examples - Recovering From Common Mistakes:

Mistakenly pressing MARK instead of END LINE at the end of a line.

First, press END LINE to halt the data acquisition. Press MENU, then highlight EDIT LINE AND MARK and press ENTER to bring up the Edit menu, shown above. Highlight DELETE BETWEEN THESE TWO POSITIONS and press ENTER. Finally, press ESC twice to return to the Acquisition Display. Then press MAP to review where data is still stored on the system, and to make sure the cursor is positioned correctly. You may need to use the arrow keys to place the cursor at the beginning of the desired line.

Mistakenly pressing END LINE instead of MARK in the middle of a line.

This case actually does not require any data or positions to be deleted. In mapped mode, all that is necessary is that you properly re-position the cursor and continue taking data. After accidentally pressing the END LINE key, press MAP to bring up the Map Display. Then, use the arrow keys to position the cursor at the mark position where you pressed the END LINE key. This position will be at the exact end of the last data segment. Next, press ESC twice to move to the Acquisition Display. Now, walk back to where you pressed the END LINE key. Press MARK and start walking. Continue the line normally.

Summary

Data editing in mapped mode is somewhat different than in simple survey mode. In mapped mode, you should visualize the survey area using the map, delete line segments or lines, then reposition the cursor where you want to go next.

To move from the Edit Menu to the Map Display, press ESC twice, then MAP. To go back to the Edit Manu, press ESC, then MENU, make sure EDIT LINE AND MARK is highlighted (it should be) and press ENTER.

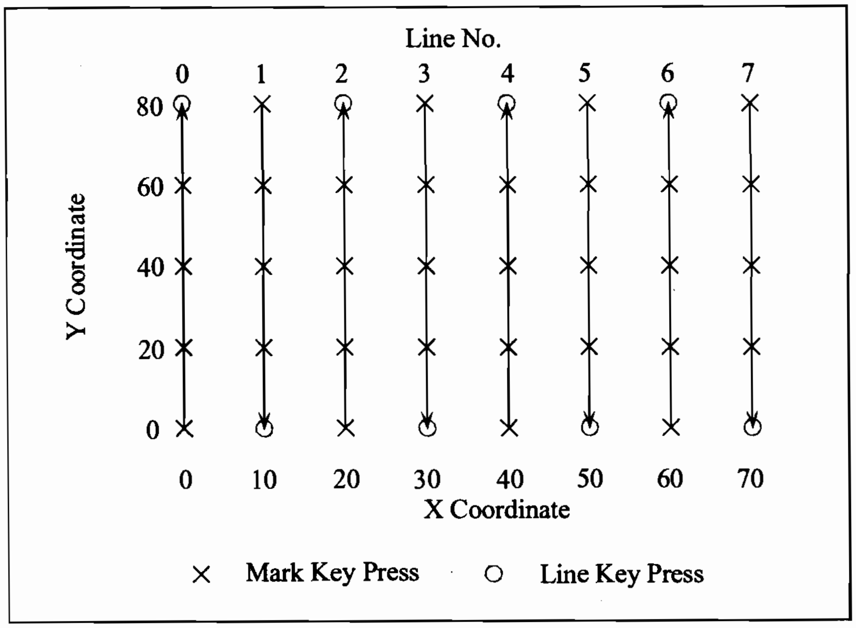
Note: It is strongly suggested that after each segment or line is deleted you bring up the map to see where you now are. Also, don't forget to check to see where the cursor has been positioned, and its direction, after the deletions are finished.

Defining a Physical Area

In the explanation above, we touched only very briefly on defining the map. This section will more clearly explain how to define the map display so that it corresponds to the mental picture you have of the actual survey site.

Normal Orientation

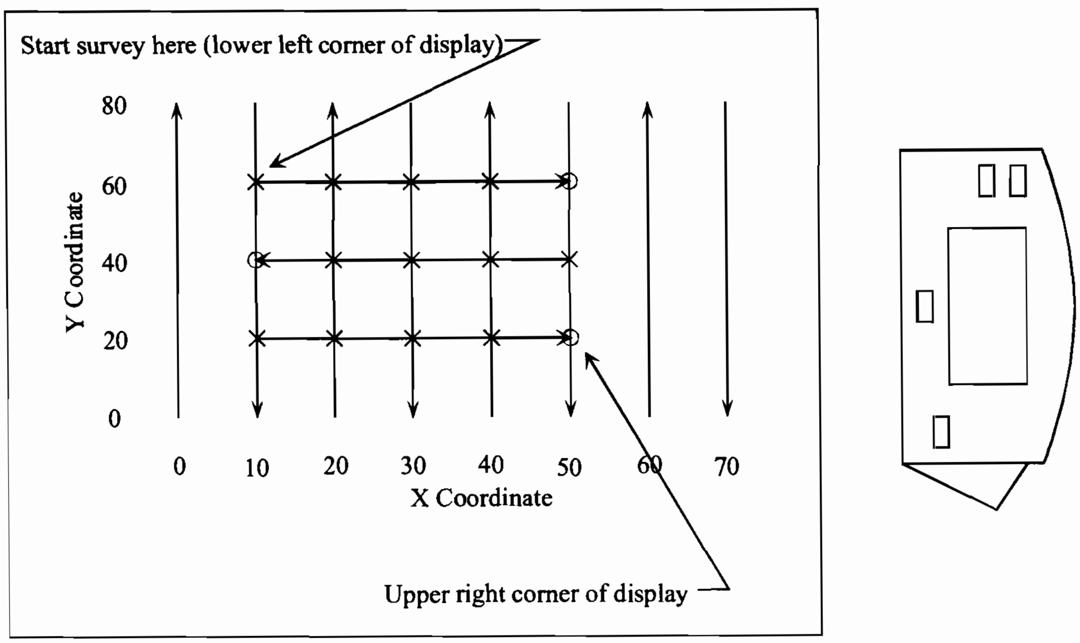
The easiest way to keep the coordinate system clear is to define the Y axis to be the direction along which you are walking, and the X axis perpendicular to that. Then the coordinates will be displayed on the G-859 in the way most people are used to seeing x and y axes, with the y axis being vertical, and the x horizontal. An example of this set up is shown below.



For this case, the lower left coordinate that you should enter in the Define Map Menu would be (0, 0), and the upper right would be (70, 80). The line spacing is equal to 10, and the mark spacing is equal to 20.

90 Degree Orientation

Suppose, however, that you have already defined the x and y coordinates, and do not wish to define the y axis as parallel to the line direction. One good reason to do this is if you are doing a smaller portion of a larger survey, and you wish the coordinates to be consistent. For example, say you want to survey a smaller area within the last survey:



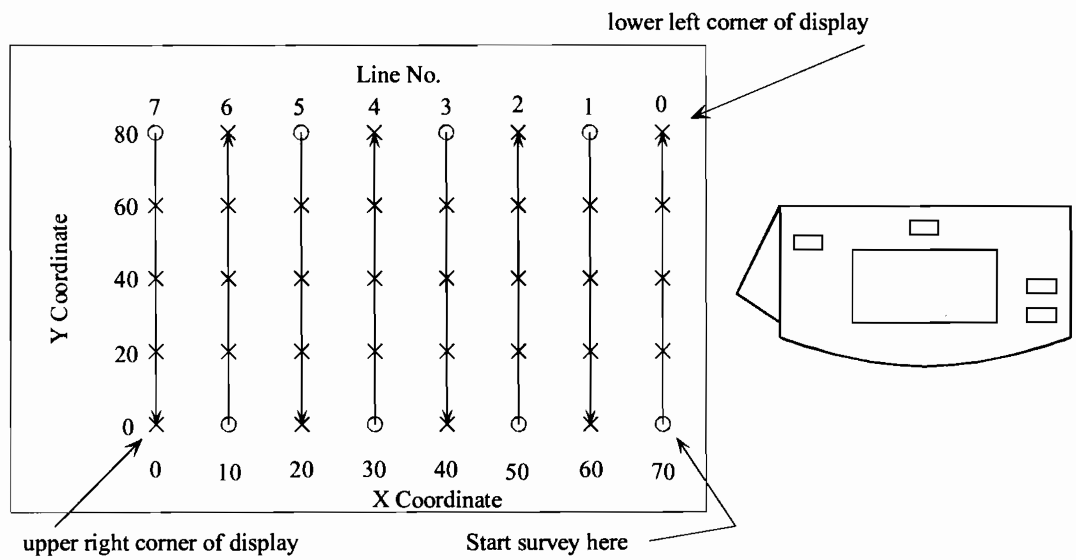
In this case, you would enter the coordinate (10, 60) as the lower left corner of the display, and (50, 20) as the upper right corner of the survey. You would also set the unit to survey parallel to the X axis. You can visualize this by rotating the G-859 clockwise 90 degrees and placing it on the map. For the sub-survey shown, the line spacing is now 20, and the mark spacing 10.

Note: Two things must be remembered in setting up the coordinate systems. First, the line direction is always up and down the G-859 display. Secondly, lines are surveyed starting from the left of the display, and moving toward the right of the display.

180 Degree Orientation

Please note that the G-859 allows you complete freedom in where to start your survey, even though the lines always must move from left to right on the display. You can always rotate the G-859 until the line direction is up and down, and the lines move from left to right. This rotation will determine what coordinate you must enter as the lower left and the upper right of the display. Some orientations will require that you start the survey in the upper left corner of the display. This can be set in the Map Setup Menu before starting the survey.

This can be seen in the following example. Suppose you are back to the original survey, shown in Figure 1, but you wish to start in the lower right corner of the site.



This can be accomplished by rotating the G-859 180 degrees relative to the site map. Then you can see that the correct lower left coordinate is (70, 80), while the upper right coordinate is (0,0). The survey should be begun in the upper left corner of the display.

Advanced Features

The G-859 has many features allowing a great amount of flexibility in defining your position and viewing the survey site. This section describes the ability to define more arbitrary positions, and re-define the survey grid.

Software States

Before discussing the advanced features, it will be helpful to define some states the G-859 can be in, in order to explain when certain operations will work.

There are 3 active states of the G-859 in continuous mode:

Acquire State.

In this state, the system is storing data, generating the woowee tone, and updating the analog sweep trace of the magnetometer output. Pressing the END LINE key sends the system to the Ready State.

Ready State.

This is the state the system is in between lines, for example. Data is not being recorded, the woowee sound is off, and the sweep trace is frozen. Pressing the MARK key sends the system to the acquire state.

Pause State.

The system enters this state from the Acquire State when the pause key is pressed.

Positioning Data

In order to interpolate a position for each individual reading, the system must have a position defined both before and after each segment of readings. Because of this, you cannot press ESC from the acquire state. This would leave a series of readings without an ending position, so the most recent readings could not be properly located.

There are two position recording keys on the G-859: MARK and END LINE. As seen above, these keys, in addition to recording the current position, control the transitions between the Ready and Acquire state. They can therefore be used to start and stop data acquisition.

Press the MARK key at fiducial positions when you want to start or continue data storage. Press the END LINE key at a position when you want to stop data storage. You don't have to be at the actual end of a line to press the END LINE key.

The END LINE and MARK keys also control the automatic tracking of the position. As you have no doubt seen, the positions are automatically updated after each position key press. The MARK key increments (or decrements) the vertical position on the display. The END LINE key advances the horizontal position 1 line spacing.

While using the END LINE and MARK keys to control data acquisition when surveying arbitrarily positioned segments, you must manually update the correct positions.

Manually Entering a Position

You may enter new positions from either the Ready or Pause state. One way to do this is to bring up the map display (press MAP) and move the cursor with the arrow keys. This will allow you to move to any fiducial point. Another way is to bring up the acquire menu (press MENU), and type a new coordinate into the G-859. This allows you to enter positions which are not directly at a fiducial point.

Note: Neither method will allow you to enter points which are not on one of the lines of the survey. To fill in more data between lines, you must redefine the grid. See the section Multi-Grid Surveys in this chapter.

If you are currently in the middle of a series of readings, i.e. you pressed the PAUSE key and haven't yet entered a position, you may only position yourself on the same line you are on.

From the Ready state, you may enter any position along the current line. You can then begin a series of readings from that point.

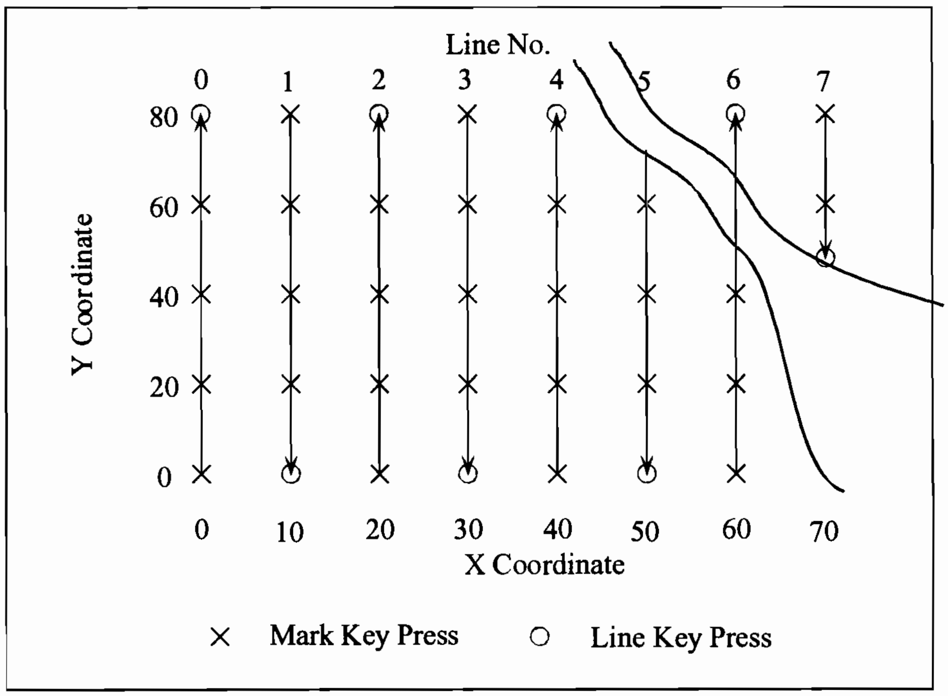
Note: Don't forget to press the ENTER key after entering the value in the numeric entry box.

Example

The principles involved in manually entering positions may best be seen by example. Consider the survey site below, where a stream crosses the survey area. This example shows how to

1. Start a new line at an arbitrary location
2. Leave a gap in the middle of a line.
3. End a line at a specified location

Before going out in the field with your G-859 we strongly suggest that you experiment with this example and observe what happens. This will save much potential confusion out in the field.



Sample Survey Containing an Obstruction.

In the above example, conduct the survey normally until you reach the end of line 4. At that point, press MENU to display the Acqure Menu. Highlight the Next Y field, and enter the value 70. (Press DEL, type 70, then press ENTER). Press ESC to return to the Acquisition Display. Position the sensor at the beginning of line 5 (Y=70), press MARK, and start walking. Proceed normally down line 5, pressing MARK at Y=60, 40, 20, and END LINE at Y=0.

Now begin line 6, by pressing MARK at Y=0, 20, and 40. Upon reaching the stream, press PAUSE. Press MENU, and enter the value 50 into the Next Y field. Press ESC. Press MARK. You have now correctly ended the previous segment of data. After fording the stream, you must enter the starting position of the next segment as described below.

Note: The position entered by an END LINE or MARK key press is the position labeled Next Position on the display. You must update this value *before* pressing the END LINE or MARK keys. If you end a segment by entering an incorrect END LINE or MARK coordinate, the data for that segment will have to be deleted and re-taken, this time with the correct final position.

Press MENU to bring back the Acquire Menu. Enter the position 65 into the Next Y field. Press ESC, then press MARK. You have now entered the starting position.

Note: Entering a value into the Next Y or Next X field in the Acquire Menu will not record the position. The MARK key must be pressed to do this, and MARK key presses are only recorded in the Acquisition Display.

To resume collecting data, press PAUSE, and start walking. Press END LINE at the end of line 6.

Note: Notice that data taking was not resumed when the MARK key was pressed. This is because you pressed the PAUSE key when you reached the stream walking up line 6. This puts the G-859 into Pause Mode, and a second PAUSE key press is used to resume data collection. Read the text at the bottom of the Acquisition Display to determine if you are in Pause Mode. If you are, it will say “Press pause to resume.” If not, it will say “Press MARK to start” In this latter case, data taking will start when you press MARK. This an important point, so to avoid confusion you should always read the text at the bottom of the display.

Start line 7 normally, by pressing MARK at Y=80 and X=70. When you reach the stream, press PAUSE. Bring up the Acquire Menu (press MENU), and enter 45 into the Next Y field (don’t forget to press ENTER). Press ESC,then press END LINE. Notice that you are no longer in the Pause Mode. The END LINE key press moves the system out of that mode.

To observe your handiwork, press the MAP key. You will see that readings are positioned correctly.

Multi-Grid Surveys

As seen above, horizontal locations are limited to grid lines. However, you can change the grid, even in the middle of a survey. This is useful if you want to fill-in parts of a survey with finer spaced lines, or take lines in different directions.

Note: The current grid is used for the automatic tracking of positions, and to define the display extents and fiducial points of the map.

From the Ready state, press ESC to bring up the Mapped Survey Main Menu. Then select DEFINE MAP. Make the changes you desire, then select CONTINUE SURVEY from the Mapped Survey Main Menu. Press the MAP key to bring up the map, and position the cursor where you desire. Then bring back the acquisition display (press ESC from the map). Pressing the MARK key will begin data storage.

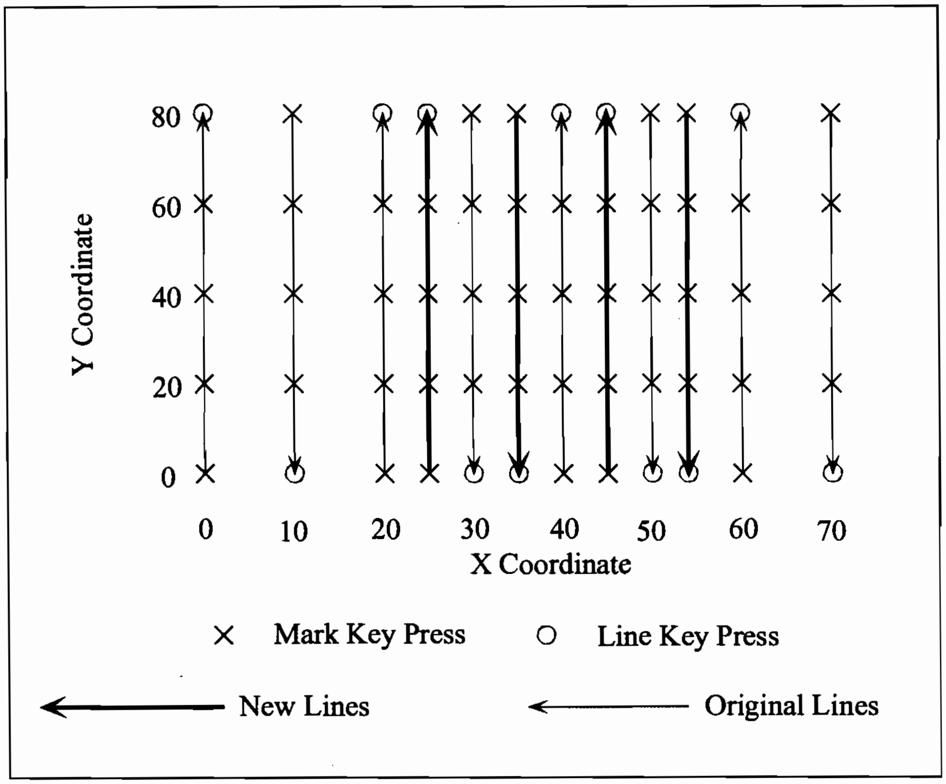
Note: Novices to the G-859 should not attempt this procedure. Another way to do this is to define a new file number, as if this were an unrelated survey. Data can then be located and edited separately, and combined in a program such as Surfer for Windows.

Warning: You may not be able to edit positions in MagMap2000 when using a multi-grid survey. If you use this function, make sure you get the positions correct on the G-859. You must use the NOEDIT method within MagMap2000 in order to locate surveys in which the lines are not parallel.

Note: The map display will only show the current grid. Thus, you may not see data points which were gathered in previous grids. In order to see all of your data points, you could re-define the grid to contain the entire area of interest.

Example 1: Filling in more lines

Suppose you have completed your survey and desire to fill in more lines over a certain portion. Consider the survey shown below.



For the first part of the survey, you would have defined the grid as follows:

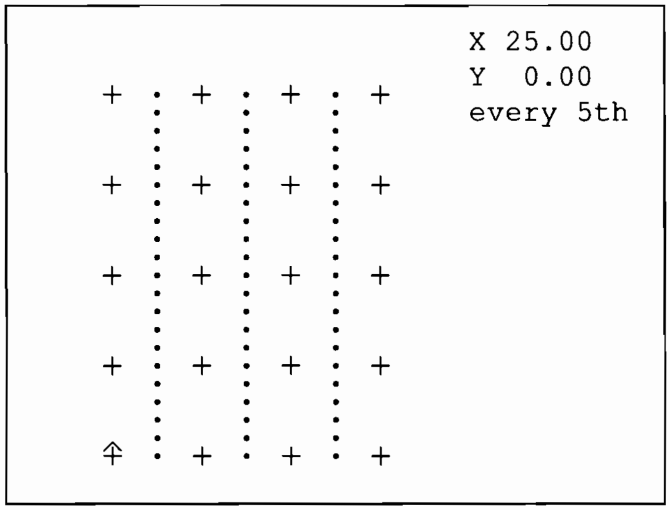
Lower left corner	X= 0.0, Y = 0.0
Upper right corner:	X = 70, Y = 80.0
Survey along	Y axis
Line spacing	10.0
Mark Spacing	20.0

When you have finished the original survey (the light dashed lines), ESC back to the Mapped Survey Main Menu, and select DEFINE MAP. Then enter the following values:

Lower left corner	X= 25.0, Y = 0.0
Upper right corner:	X = 55, Y = 80.0
Survey along	Y axis
Line spacing	10.0
Mark Spacing	20.0

Next, press ESC, then select CONTINUE SURVEY.

Pressing the MAP key will now show what you have done. You should see the following display:



The readings taken for the previous grid are shown. The extent of the map covers only the current grid. However, all data previously taken is still stored in the G-859. You are now ready to survey the new lines in the normal fashion.

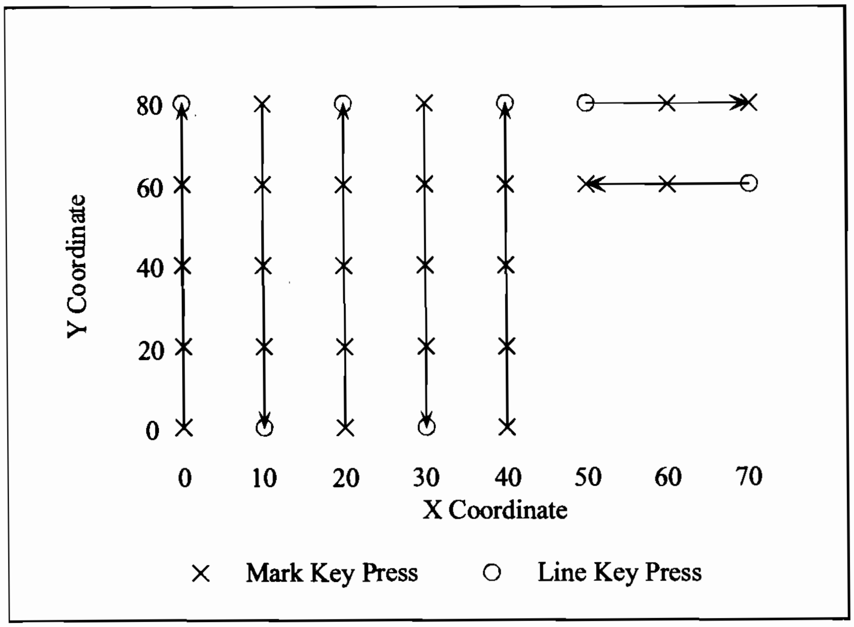
Note: The chart display will not show the old and new lines in the correct order when a multi-grid survey has been performed. The cursor coordinates displayed on the chart display will be correct, however.

Make sure the cursor is positioned where you want it to be. Sometimes, the cursor may not be shown, as it is positioned out of the displayed area. From the map, press MENU, then enter the desired cursor position (X=25, Y=0 in this case). Press ESC to return to the map, and the cursor will be positioned correctly.

After taking all the data of interest, you can confirm that all the data from both grids is still in the G-859. You may do this by re-entering the original grid in the map definition menu, pressing ESC, selecting CONTINUE SURVEY, and pressing MAP.

Example 2

You may also wish to take lines in perpendicular directions. Consider the survey shown below.



For the first part of the survey, define the grid as follows:

Lower left corner	X= 0.0, Y = 0.0
Upper right corner:	X = 40, Y = 80.0
Survey along	Y axis
Line spacing	10.0
Mark Spacing	20.0

When you have finished that, ESC back to the Mapped Survey Main Menu, and select DEFINE MAP. Then enter the following values

Lower left corner	X= 50.0, Y = 80.0
Upper right corner:	X = 70, Y = 0.0
Survey along	X axis
Line spacing	20.0
Mark Spacing	10.0

Then take the next two lines of data. When you download the data, you will be able to locate the points correctly.

Note: MagMap2000 will not be able to edit a survey such as this. You will need to locate the data using the NOEDIT option in MagMap2000. See Chapter 4 for details.

Chapter 7: Base Station

In base station mode, the unit will not keep track of changes in position. This is most useful when the unit is being used to collect data for diurnal correction of another, roving, unit's data. This procedure is accomplished in the post-processing of your data, using the MagMap2000 program. See Chapter 4 for more details.

In addition, this mode supports a real-time transfer of data out of the RS-232. This is useful if you are using another PC to collect and process the data. Of course, you may also store the data inside the G-859, with or without real-time transfer.

Setting up a Base Station Survey

From the main menu, select BASE STATION. The base station main menu will appear:

```
          --- BASE STATION MAIN MENU ---
              File < 1 >  MAG  EMPTY



     Read Mode:         <   TIMED  >
     Store Mode:  < STORE & TRANSFER TO PC >
            Baud rate     <  9600   >
Cycle Time:         [ 0.2       ] s
                  START NEW SURVEY
      10:40:10  02/18/95  Memory Free  86.6%
```

Base Station Main Menu

Scroll to an empty file, or select the base station file you wish to append data to. The fields are as follows:

Read Mode.

May be set to TIMED or TRIGGERED. In TIMED mode, data will be read at timed intervals, set by the cycle time field in this menu. In trigger mode, data will be read and stored by pressing the MARK key.

Store Mode

May be set to STORE IN MEMORY ONLY, STORE AND TRANSFER TO PC, or TRANSFER ONLY. Transferring data means sending it out the serial port as it is being collected. Storing means storing the data in the on-board memory.

**NOTE: If the STORE IN MEMORY AND TRANSFER option is selected, then when the memory if full, after 5 or 6 hours the magnetometer WILL STOP TRANSFERING DATA. For this reason, if long term unattended base station use is considered, we *strongly suggest you use the TRANSFER ONLY* setting. Then the magnetometer will continue to take readings and transmit them as long as there is battery power.

Baud rate

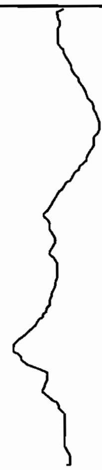
This field is shown only if transferring to PC was selected in the above field.

Cycle Time

Sets the time interval between readings. Also sets the measuring interval. Increasing the measuring interval will increase the sensitivity of the magnetic reading. Setting the cycle time to greater than 1.5 seconds will change the time between readings, but will not affect the sensitivity.

Acquiring Data

Once the parameters have been set to your satisfaction, highlight START NEW SURVEY and press Enter to begin data collection. The base station acquisition menu will be displayed, as shown below.

BASE STATION Field: 0.00 STORE:YES TX PC: NO EVERY CYCLE QC: 0.00 Scale: 50 Adjust: "MENU"	

Base Station Acquisition Display

To adjust certain parameters, press the MENU key to bring up the adjust menu: This will allow you to set the volume, the scale, the woowee pitch and sound level, and center the trace.

BASE STATION Field: 0.00 STORE:YES TX PC: NO EVERY CYCLE QC: 0.00 Scale: 50 Quit: "ESC"	Master volume: < 4 > Woowee: < 4 > Volume: < 4 > Sensitivity: < 4 > Hz/nT QC warning Volume: < 4 > Level: [9.999] nT Full scale: < 50 > nT Rdngs/screen: < 25 > Cycle time: [0.2] s CENTER TRACE

Base Station Adjust Menu

The audio and scale may also be adjusted directly from the acquisition menu.

Audio Key

Pressing the audio key will bring up an audio adjust indicator. Then the up and down keys will adjust the volume, while the right and left arrows will adjust the pitch of the woowee. The audio adjust indicator will disappear after a few seconds.

Scale Key

Pressing the scale key will bring up an scale adjust indicator. Then the up and down keys will adjust the speed of the sweep (readings shown per page), while the right and left arrows will adjust the full scale (in nT). The scale adjust indicator will disappear after a few seconds.

Chapter 8: Data Review

Enter the Data Review mode by selecting DATA REVIEW from the main menu. An example display is shown below. Your display will differ, depending upon the type of survey used for a particular file number.

--- DATA REVIEW MENU---

File < 1 > MAPPED SURVEY

	Start	End
Time	01:38:45	02:40:34
Date	03/03/95	03/03/95
X	0.00	100.00
Y	0.00	100.00

File Size: 471 Readings: 115

DO DATA REVIEW

17:52:23 04/24/03 Memory Free 99.9%

This menu shows the directory of each survey stored in the G-859. Scrolling the file number will scroll through the files.

Selecting DO DATA REVIEW brings up the chart display for the selected file number.

Chart Display

The chart display varies slightly depending upon whether the survey is a simple survey, mapped survey, or base station.

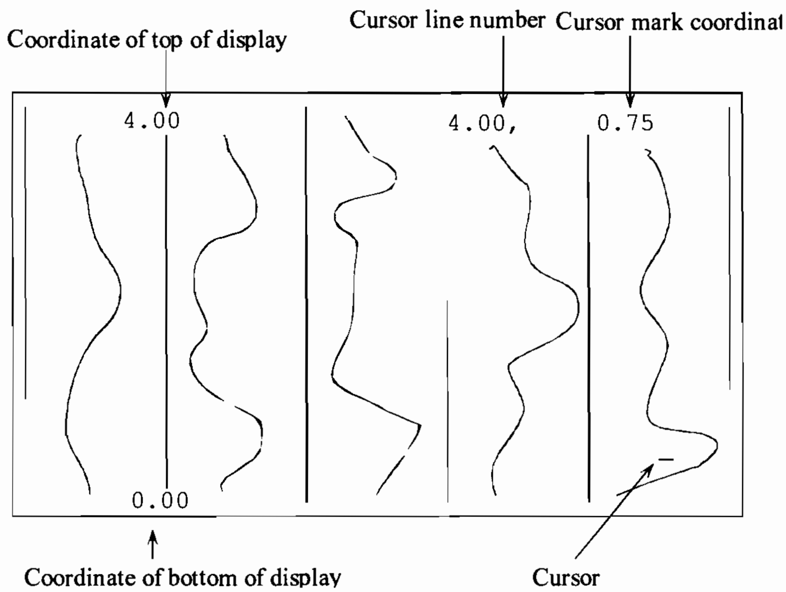


Chart Display for Simple Survey

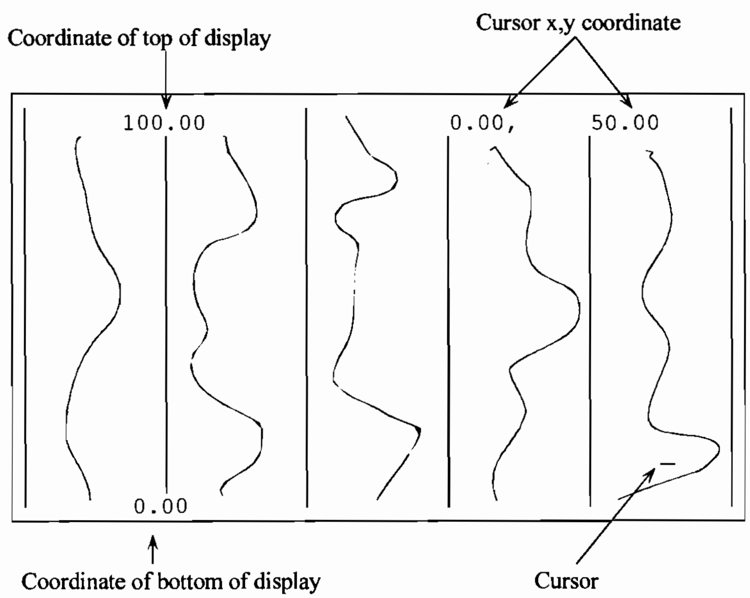


Chart Display for Mapped Survey

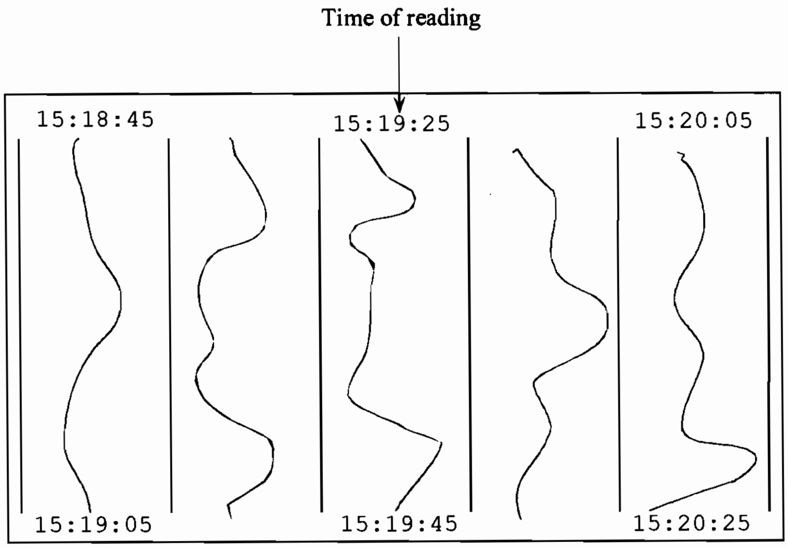


Chart Display for Base Station

The chart display shows profiles of 5 lines of data at a time. The vertical position of the display window is shown on the upper and lower left of the display. The upper right corner shows the x and y position of the cursor.

Data Review Menu

Pressing the MENU key brings up the data review menu

```
                DATA REVIEW MENU


     Move to position
          Line:     [    6    ]
          Mark:     [    0    ]


     Full Scale:   <   50    >    nT


     Zoom to show <  ALL   > of line
```

Data Review Menu

The data review menu allow you to go directly to a desired position to view the data without tediously scrolling with the arrow keys. You may also change the horizontal scale, or the vertical scale.

Move to position

You may enter the Line and Mark numbers you which to jump the cursor to in these numeric entry fields. Don't forget to press the Enter key after entering the number.

Full Scale

This shows the horizontal full scale, in nano Teslas of each profile column. The data line will "wrap around" to stay within the window. In other words, if the data line moves off the right side of the column, it will reappear at the left side of the column if the field increases slightly.

Zoom

This field sets the vertical scale of the display. You may show all of the line, or portions of a line by scrolling through this scroll box with the left and right arrow keys.

If the vertical scale include only a portion of the entire line, you may scroll up the display by moving the cursor with the arrow keys.

Chapter 9: Data Transfer

Selecting DATA TRANSFER from the Main Menu will bring up the data transfer menu:

```
---DATA TRANSFER MENU ---
PC CONTROLLED TRANSFER
MANUAL ASCII TRANSFER
ERASE DATA SET
!!! FORMAT MEMORY !!!
SEND SET UP
RECEIVE SET UP

11:52:44  04/24/03  Memory Free 99.9%
```

Data Transfer Menu

This menu allows you to transfer data in either binary form or ASCII form. ASCII data is human readable, but takes about 100 times as long to download. It is suitable only for the smallest files.

Attach the serial cable (supplied with the unit) to the serial port. The other end connects to your PC. Some computers may require a 9 pin to 25 pin serial adapter, available from your computer store. You will need to know which serial port (typically COM1 or COM2) you have attached it to.

PC Controlled Transfer

Allows transfer of data in binary format. Data will be downloaded under the control of the MagMap2000 program on your PC. You must select this option on the G-859 console, then select download from the MagMap2000 program. See Chapter 11, for details on running MagMap2000. You will also need to know which file number you want to transfer. You may select MANUAL ASCII TRANSFER to page through the files to see which one you want to transfer. Then press ESC to return to this menu, then select PC CONTROLLED TRANSFER.

Manual ASCII Transfer

This allows data to be transferred in ASCII format. See the section below for the sub-menus under this option.

Erase Data Set

This allows a particular data set (file) to be erased. See the section below for details.

PC Controlled Transfer

Select this option, then run the MagMap2000 software. There, under the Import item of the main menu, you will find options for downloading data. See chapter 11 for more details on running MagMap2000.

Manual Ascii Transfer

Selecting Manual ASCII TRANSFER will bring up the following menu

---MANUAL ASCII TRANSFER MENU

File < 1 > MAG MAPPED SURVEY

	Start	End
Time	01:38:45	02:40:34
Date	03/03/95	03/03/95
X	0.00	100.00
Y	0.00	100.00
File Size: 471	Readings: 115	

Baud Rate < 9600 >

START TRANSFER

11:52:44 04/24/03 Memory Free 99.9%

You may scroll through the file numbers to the desired data set. Then select the baud rate. Next, you must set up your communications program on your PC. When you highlight START TRANSFER and press Enter, data will be sent out the serial port.

Erasing a Data Set

Selecting ERASE DATA SET will bring up the following menu

---ERASE DATA MENU---

File < 1 > MAG MAPPED SURVEY

	Start	End
Time	01:38:45	02:40:34
Date	03/03/95	03/03/95
X	0.00	100.00
Y	0.00	100.00
File Size: 471	Readings: 115	

!!! DATA SET NOT TRANSFERRED !!!

DELETE THIS DATA

11:52:44 04/24/03 Memory Free 99.9%

Scroll to the desired file number. Then select DELETE THIS DATA. You will be prompted with a dialog box before the file is actually erased. You will not be able to recover any file that you have deleted. Notice the warning message on the menu above for file numbers that have not been transferred. If you have transferred data from this file, this message will not be shown.

Format Memory

Erases the entire data memory of the G-859. All data in all files will be lost. If the system hangs up at some point, you may need to do this after power up to get the unit to behave properly.

Send Set Up

Intended for Geometrics Service and Test.

Receive Set Up

Intended for Geometrics Service and Test.

Chapter 10: GPS Programming

Overview

The G-859 is designed to simultaneously acquire GPS positions while it is acquiring magnetic data. The NovAtel Smart Antenna GPS is preset at the Geometrics factory to send the smallest possible $GPGGA position and time string in order to maximize memory utilization. The magnetometer interface for logging the GPS position data is also preset, and so the only requirements are that the user start the survey in either Simple Survey or Mapped Survey mode and the GPS information will be automatically logged. The console is set up so that the GPS is not logged when in Pause or at the End-of-Line. Again this is to maximize memory space.

The G-859 may be programmed to send commands to the GPS receiver when certain keys are pressed. All communication with the GPS takes place through the RS-232 port.

Note: Please remember that ASCII strings coming from a GPS unit take up a lot of memory space. Select the smallest data format you can for maximum data collection time. With a GPS unit sending a data string every 1 second in NMEA GGA format, for example, and the G-859 set to collect 10 readings per second, the memory will be full after about 3.5 hours.

Collecting GPS Data

Most G-859 magnetometers are equipped with a Novatel Smart Antenna GPS mounted on a backpack frame. These GPS units are cabled to the G-859 logging console and pack frame battery box. All necessary wiring connections are in the power cable supplied with the battery box. The Smart Antenna is pre-configured by Geometrics to provide the $GPGGA NMEA sentence only.

Make sure that the RS-232 port is set to collect GPS data. This is done in the main System Setup menu. Set the RS-232 port to DATA LOGGER. In addition, you will probably want to set the unit to store GPS data only when in the acquire mode. This means it will store GPS data only when magnetometer data is being stored. Therefore, between lines or when in PAUSE mode, no GPS data will be stored. This will save memory, and typically you will not be interested in GPS data during those times.

There is no need to program the NovAtel Smart Antenna GPS unless the GPS memory has become corrupted and it has lost its programming. If that were to occur it could start sending improper GPS serial data. If so, we recommend the following procedure:

NovAtel Smart Antenna Setup Version 1.2

Required Equipment:

1. Windows 98 – XP PC with RS 232 Serial port
2. HyperTerminal software
3. Novatel L1 StarView software
4. P/N 25358-20 Geometrics adapter cable (supplied with every system) which connects to the GPS interface cable wired into G-859 Pack Frame

Procedure

1. Turn off the battery box GPS power switch.
2. Connect the 25358-20 cable between the GPS serial cable wired into the pack frame (disconnect the serial cable from the G-859 console) and a serial port on the computer.
3. Turn on the battery box GPS power switch
4. Start the StarView software.
5. Set communications to 8 data bits, No parity, 1 stop bit, and 9600 baud.
6. Set the GPS to start with NMEA $GPGGA at 1 second rate.
7. The Smart Antenna is capable of SBAS (WAAS) positioning. If this is desired and the satellites are available in your survey area you must perform this additional step. Select *tool settings* | *Deselect*| *SVs* from the main menu. To track SBAS (WAAS) satellites select SBAS SVs and click on the *Send* button. To track GPS satellites, select *GPS SVs* and click on the *Send* button again. Refer to the *Star View User Manual* for more information. By default, if you select WAAS SVs alone, the unit is only searching for satellite PRNs 120, 122, and 134. Select *Status* | WAAS from the window menu to see the number of valid SBAS messages that are being decoded for a specific SV number since the last power-up. When the *Valid Messages* count is not incrementing, either the receiver is not tracking any SBAS satellites, or it's unable to read the SBAS data. If you have any trouble with your Smart Antenna, please contact NovAtel Customer Service at Email: support@novatel.ca, or by telephone at 403-295-4900.
8. Stop the StarView software.
9. Turn off the battery box GPS power switch.
10. Start Windows HyperTerminal™ and connect to the selected COM port at 9600 baud, 8 data bits, 1 stop bit, No parity, and No flow control.
11. Turn on the battery box GPS power switch.
12. Observe correct $GPGGA data.
13. Disconnect the P/N 25358-20 adapter cable and reconnect the GPS serial cable to the G-859 console.

Interfacing with User Supplied GPS Receivers

The RS-232 port of the G-859 is extremely versatile. The set-up procedure for RS-232 communication is sometimes complex, meaning that you will need to carefully study this section and experiment to get user supplied (non-Novatel SmartAntenna™) external GPS equipment to work with the G-859.

Before connecting your GPS to the G-859, please make sure you completely understand how to operate the GPS system. GPS receivers will send data out in many formats, and you must know what commands will tell it to give you the data you wish. You may then program the G-859 to send these commands to the GPS receiver.

The next step is to program the commands needed by the GPS unit into the G-859. This is done by selecting EXT RS-232 & FIELD NOTE SETUP from the main System Setup menu. See the section earlier in this chapter for information on programming keystrokes to send commands to the GPS.

You will need to connect the GPS to the G-859 using the proper serial cable. Most GPS units will require a null-modem adapter between the supplied RS-232 cable for the G-859 and the GPS port. Contact Geometrics for the availability of a cable specially designed for connecting directly to a GPS system.

Once the GPS system is connected, you will need to actually send it the commands you have previously programmed into the G-859. This is most easily done in the CHAT MODE of the EXT RS-232 & FIELD NOTE SETUP. Select CHAT MODE, then press the desired keys to send the associated command. You will be able to observe the response of the GPS system from within chat mode. Make sure it is operating properly.

Now you are ready to log GPS data. Start your desired survey as usual. You will notice a bar indicator which when moving indicates that data is coming in on the RS-232 port.

Using GPS data

The GPS data stored during a survey is embedded within the magnetometer and other positioning data. You should upload this data into MagMap2000 where you can filter and plot GPS positions, magnetometer data, destripe (remove heading error), contour and plot the data. Interpolating the magnetometer data with GPS data is all done automatically and we recommend that you use the MagMap2000 program to position the data with GPS or UTM coordinates. Visit www.geometrics.com to download the latest version of MagMap2000.

If you want the GPS positions and time in a separate file, you must manually extract the GPS data from the magnetometer binary file. To manually extract the GPS positions from the file, perform the following procedure. First, download the binary file using the MagMap2000 program. If you wish, you can also do any other MagMap2000 function, such as locating the data or doing a diurnal correction. Remember the name of the binary file (`.BIN` extension) you used as the output file name when downloading the G-859 data (Import / Download). Exit the MagMap2000 program.

From the DOS prompt run the following program:

`BINTOASC` *`input`*`.bin` *`output`*`.gps -R0 -M0 -D0 -P0 -U0 -F0`

where

`input` is the name of the file containing the binary downloaded data (you must type the .BIN extension

`output` is the filename you wish for the GPS data (you must give it an extension. The `GPS` extension is a suggestion, however, you may use what you wish.)

`-R0 ...` The options tell the program not to extract everything except the RS-232 serial strings. They are a dash, a letter, and the numeral zero.

You will now have created a file of the GPS strings, along with some G-859 formatting information. Lines will be as shown below:

`21` *`DATA_STRING`* `Date Time`

Example (Line is broken only to fit on page. It is actually a single line in the file.)

```
21 $GPGGA,175748.00,3726.0363,N,12210.0318,W,0,6,001.1, 00024.6,M,-
028.4,M,031,0000*6C 10:59:14.80 06/01/95
```

The 21 at the beginning of the line indicates this string came in the RS-232 port of the G-859. The string is followed by a date and time stamp from the G-859. This may be used to correlate the positions with the magnetometer readings, which are also time stamped.

Chapter 11: System Setup

Selecting SYSTEM SETUP from the main menu brings up the following menu.

```
                 ---SYSTEM SETUP MENU---
                          AUDIO
                       DATE & TIME
                     COM PORT SETUP
                 COM & FIELD NOTE SETUP
                   MAGNETOMETER TEST
Real time transfer:       <  DISABLE  >
Use COM1 port as:
           <  ASCII CHARACTER LOGGER  >
                  <  CONFIGURE  >


Store serial data in:     < ACQUIRE MODE >
QC warning level:         [ 9.999   ] nT
```

System Setup Menu.

Audio

This allows you to set several parameters relating to the volumes and frequencies of the various audible tones. See below for more details.

Date & Time

Selecting this will allow you to set the date and time. See below for more details.

Com Port Setup

Selecting this will allow you to set the functions and baud rates of COM1 through COM4. This sets the baud rate of the serial for both incoming and outgoing data. Rates are selectable from 1200 to 115200. The system default is 9600. See below for more details.

Com & Field Note Setup

This allows you to define ASCII text strings to be either sent out the serial port or stored as field notes. Sending strings out the serial port is useful for controlling a GPS system. Field notes are useful to mark any desired event.

Each string is associated with a particular key press. During a survey, pressing the key will cause the associated string to be either stored as a field note, or sent out the RS-232 port as a command. See below for more details.

Magnetometer Test

This selection opens a screen that provides information about the state of operation of the Magnetometer. Also presented are a selection of internal volatages that indicate the state of the system. See below for more details.

Real Time Transfer

Enabling real time transfer will cause data to be sent out the serial port during the acquisition. The data coming out will be formatted exactly as for the ASCII data transfer. The setting will not affect whether or not data is stored inside the G-859. The options here are 'DISABLE' and 'ENABLE'. When EM-61 data is being acquired this should be set to 'DISABLE'. Sending data in real time to the EM-61 causes the EM-61 to report a huge[*] number of errors.

[*] huge = large enough to cause trouble. The G859 gets bogged down processing these error messages.

Serial Port (Use COM 1 as:)

There are several options for the use of COM 1 as follows:

SIMULATED KEYBOARD
ASCII CHARACTER LOGGER
GEOMETRICS MODULE LOGGER
FRAMED BINARY LOGGER
RAW BINARY LOGGER
EM-61 WITH MAGNETOMETER
EM-61 LOGGER

The "SIMULATED KEYBOARD" mode allows COM1 to appear as an external keyboard, in which case ASCII characters are interpreted as keypad presses. Using your favorite communication package on your PC, you can send key presses to the G-859. The built-in Microsoft Windows accessory Terminal works fine. See the section below **How to Download Commands from the PC.**

The "ASCII CHARACTER LOGGER" mode is used to log RS-232 strings are stored in memory as they come in through the COM 1 port. Up to three numbers from COM1 may also be displayed while acquiring data. The display of these numbers may be configured in the "CONFIGURE" line that appears below the " ASCII CHARACTER LOGGER" entry in the scroll list. None to three numbers may be selected and each number may be independently adjusted for bias, scale and 0 to 3 decimal places to display.

The "GEOMETRICS MODULE LOGGER" mode is used to log data from all products that comply with the "GEOMETRICS MODULE" format. These include the CM201, the CM221, the G880, the G881 and the OhmMapper. Readings from these can be used in place of the G859's sensors. The display of these numbers may be configured in the "CONFIGURE" line that appears below the "GEOMETRICS MODULE LOGGER " entry in the scroll list. Up to two numbers with decimal points may be detected and logged as magnetometer field values. Zero to three numbers may be selected and each number may be independently adjusted for bias, scale and 0 to 3 decimal places to display.

The "FRAMED BINARY LOGGER" mode is currently only used with the MineLabs EM system. The readings from this are used in place of the G859's sensors.

The "RAW BINARY LOGGER" mode would only be needed if what is being received is binary data of a format other than "FRAMED BINARY". Each received byte is simply converted into two hexidecimal digits "0..F" and stored.

The "EM-61 WITH MAGNETOMETER" mode allows an EM-61 to be connected and logged as ASCII while a magnetometer sensor is also connected. The odds of an EM-61 not interfering with the magnetics measurement are very near zero, but if it can be done, the G859 is ready for it. The EM-61's battery voltage will be displayed as described below. The logging of the EM-61 may be configured in the "CONFIGURE" line that appears below the "EM-61 WITH MAGNETOMETER" entry in the scroll list.

When cycling is set to "G859 timing", the EM-61 will be commanded to cycle by the G859. The command will be sent at the rate specified by the G859's cycle time setting.

The EM61 system has a built in encoder on one of its wheels. If you wish to use this you should select the "wheel encoder" option here. The cycle time setting of the G-859 will only serve as a time out time for receiving data from the EM-61. The EM-61 will send its data based on the rotation of the wheel.

The "manual button" mode is very like the "wheel encoder" mode. In this case the manual button on the EM-61 will cause a measurement.

After processing the EM-61's data to make a reading, you have three options of what to do with the string from the EM-61.

The "THROW AWAY THE REST" option means just that. The battery voltage and the "fine time" from the serial data will be discarded.

The "STORE THE REST AS SERIAL DATA" option causes a serial string consisting of only the battery voltage to be stored along with the "fine time" information.

The "STORE ENTIRE STRING AS SERIAL" option causes everything that came from the EM-61 to be stored as serial data as well as being stored in place of magnetics readings.

The "EM-61 LOGGER" mode allows the readings from the EM-61 system to be used in place of the magnetometer readings. Whenever the G859 is placed in any of the acquire modes (Search, Simple survey, Mapped survey) the battery voltage from the EM-61 will be displayed as a three digit number in the upper left part of the screen. . The logging of the EM-61 may be configured in the "CONFIGURE" line that appears below the " EM-61 LOGGER " entry in the scroll list. See the "CONFIGURE" line explanation just above.

Storing Serial Data (Store serial data:)

The storing of input ASCII text may be set to occur only when magnetic data is being recorded, "WHEN ACQUIRE" is selected (see the description of Acquire mode), or whenever the display is in the active state, "ALWAYS" selection (Acquire, Ready, or Pause modes). For a GPS system, you will typically be interested in collecting data during the Acquisition mode only.

Warning: Data will never be stored if the unit is displaying a menu, the map, or the data review profiles.

QC Warning Level:

This sets the level above which the QC will causes a warning tone to be sounded.

Audio Setup

There are several audible indicators on the G-859. Selecting AUDIO will bring up the following menu.

```
                    AUDIO SETUP MENU

        Master Volume                        <  4  >
        Metronome Volume                     <  4  >
        Metronome cadence (Beeps/min)        [  60 ]
        Woowee volume                        <  4  >
        Woowee sensitivity                   <  4  >
        Warning volume                       <  4  >
        QC warning volume                    <  4  >
        Mark/line key event volume           <  4  >
```

Master Volume

This field adjusts the level of all the sounds. 0 is the quietest, 9 the loudest.

Metronome Volume

This adjust the volume of the metronome. This metronome may be set to help you maintain a steady pace when surveying a site. 0 is the quietest, 9 the loudest.

Metronome cadence

This adjust the frequency of the metronome pace.

Woowee volume

The "woowee' is the audible indicator of field strength. It is particularly helpful when searching for anomalies in Search Mode. This sound is active only in continuous survey mode.

Woowee sensitivity

The frequency of the woowee noise changes with changing field strength. This number represents the amount of frequency change per increment in field strength. If the field is fairly smoothly varying, set this to a higher number. For fields with large variations, set to a smaller number.

Warning volume

This sets the volume for warning tones.

QC warning volume

This sets the volume of the QC warning tone.

Mark/line key event volume

This sets the volume of the key click noise when you press a position key

Setting the Date and Time

Selecting DATE & TIME form the System Setup Menu will bring up the following display.

```
                DATE AND TIME MENU

                      Date
               Month:    [ 2  ]
               Day:      [ 2  ]
               Year:     [ 95 ]


                      Time
               Hour:     [ 13 ]
               Minute:   [ 30 ]
               Second:   [ 00 ]

                 SET TO ABOVE VALUES

                 12:01:12   02/22/95
```

Date and Time Menu.

Enter the correct values in the numeric entry fields. Don't forget to press Enter after entering the value. Then highlight SET TO ABOVE VALUES and press Enter.

COM Port Setup Menu

Selecting COM PORT SETUP from the System Setup Menu will display the following menu:

```
        ---COM PORT SETUP MENU---
COM1 and COM4 PORT MODE: < 1 >
   COM1 is RS232 I/O
   COM4 is RS232 input
COM2 and COM3 PORT MODE: < 1 >
   COM2 is RS232 I/O
   COM3 is RS232 I/O
COM1 baud rate:     < 9600 >
COM2 baud rate:     < 9600 >
COM3 baud rate:     < 9600 >
COM4 baud rate:     < 9600 >
```

COM1 and COM4 Port Mode:

Mode 1 is COM1 is RS-232 I/O and COM4 is RS-232 input.
Mode 2 is COM1 is RS-232 I/O and COM4 is pulsed input.
Mode 3 is COM1 is RS422 input and COM4 disabled.

COM2 and COM3 Port Mode:

Mode 1 is COM2 is RS-232 I/O and COM3 is RS-232 I/O.
Mode 2 is COM2 is RS422 input and COM3 is disabled.

COM(x) baud rate:

The selections available for baud rates are:

1200

2400
4800
9600
19200
15200

The factory default is 9600.

External RS-232 and Field Note Setup

Selecting this item will bring up the following menu:

```
          --- EXT RS-232 & FIELD NOTE SETUP ---

   Assign key <  0      >  To  < RS-232 CMD     >
                    DELETE COMMAND
            DOWNLOAD ALL COMMANDS FROM PC
                       CHAT MODE

   Press Mark to add current char to cmd
   Press Del to remove last char from cmd
   Press Map to add a comma to cmd
   Press Mumeric key to add digit to end

                Current Char  <  !  >

              Current Command/Field note:

  ------------------------------------------

  ------------------------------------------
```

Assign Key Field

This scroll list sets which key press is associated with the ASCII string.

Function Field

This scroll list sets up the key as either a RS-232 Command or a Field Note. RS-232 commands are sent out the serial port, while field notes are stored in the internal memory.

Delete Command

Pressing ENTER on this field will delete the entire command from memory.

Download all commands from PC

You may download an ASCII file from your PC to set up the entire set of commands. This is strongly recommended, since entering them from the scroll list below is very tedious. See the section below on how to set up and transfer a file of commands from your PC.

Chat Mode

This will enable you to observe the ASCII text coming from whatever device is connected to the serial port.

Current Character

You may scroll through this list to the desired character to add to the present command. Pressing the MARK key will add it to the end of the command. As a handy shortcut, you may press any numeric key to add a numeric character. There is no way to insert characters in the middle of the command. This manner of entering a command is so tedious, we recommend using it only if you forgot to download a needed command when you were near a PC.

How to Download Commands from the PC

Use your favorite ASCII text editor (DOS Edit or Windows Notepad are easy and readily available) to create a file as shown below:

```
G859CMD,00,$PASHS,NME,SAT,A,ON
G859CMD,01,$PASHS,SPD,B,2
G859CMD,02,$PASHS,RTC,REM,B
G859CMD,03,$PASHS,RTC,BAS,A
G859CMD,04,$PASHS,RTC,TYP,9,1
G859CMD,05,$PASHS,NME,GGA,A,ON
G859TXT,06,Fell into a hole
G859TXT,07,Dropped the magnetometer
G859END
```

The first six lines set up RS-232 commands. The keyword G-859CMD determines this. The second field, the two digit number, specifies which key the command or note is associated with. The numbers 00 through 09 correspond to the number keys on the console. The other keys are as shown below:

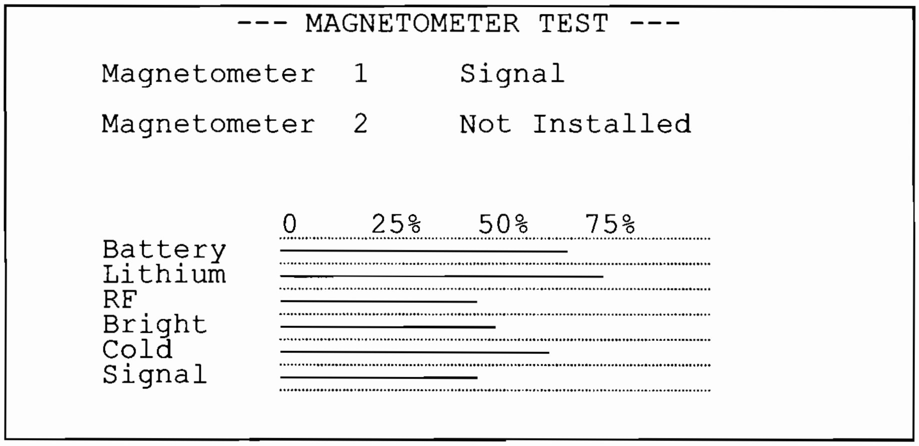
10	MARK	15	CHART
11	LINE	16	MAP
12	PAUSE	17	ENTER
13	ESC	18	POWER
14	MENU		

Note: The ASCII commands or field notes will only be active during the one of the active modes of operation. These are the Ready state, Acquire state, and Pause state, as explained on page 53.

Each key also retains its normal function. For example, if the MARK key is assigned to an RS-232 command, pressing it will still perform the normal MARK key function. This is useful, for example, if you wanted to store a GPS reading only at each MARK location. Then, you would program the MARK key with the command to query the GPS for the current position. In doing this, you would probably also want to program the END LINE key with the same command. Then, you will get a GPS confirmation at each fiducial point.

Magnetometer Test

The magnetometer test brings up the following display:



Magnetometer Test Display.

The first two lines, showing the status of the sensors, are very useful to watch if no signal is seen, and during system warm-up.. The possible states of the sensor are as follows:

Not installed. Indicates the sensor is unplugged.

Initializing. Checking for presence of sensor.

Warming Up. Sensor is being warmed up to the operating point. This may take several minutes in cold temperatures.

Starting Lamp. Energy is being applied to the sensor lamp to try to strike it. Should occur only briefly after sensor is warmed up.

Running up. Cesium cell is being warmed up to the desired temperature.

Regulating. Cell is operating, apparently normally, but a valid signal is not present. Usually occurs due to high field gradients, or the field being in a dead zone.

Signal. Sensor is reading a valid signal.

Failed. There was some problem in either striking the lamp or maintaining the desired brightness or temperature. Usually, unplugging the sensor and plugging it back in will eliminate the problem.

Next, the graph shows various internal voltages. A description of each item follows:

Battery: Indicates the voltage of the main battery. Full power is shown as 60%.

Lithium. Indicates the voltage of the internal lithium battery, which is responsible for storing data and setting when the unit is turned off. Normal operating range is 65% to 75%.

RF Indicates the drive level being applied to the cesium sensor lamps. Normal operating range is 25% to 75%.

Bright Indicates the resulting lamp brightness. Should be maintained at 50%. During warm up, this voltage will slowly settle at that value.

Cold Indicates the cesium cell temperature. Should be maintained near 50%. Larger numbers mean cooler cells.

Signal. Indicates the signal strength. Signal strength is a funciton of cell orientation and field value. Normal strengths are between 5% and 25%.

Chapter 12: MagMap2000 Software

The MagMap2000 software program provides the G-859 user with data downloading and editing capability. Acquired data is downloaded via high speed RS-232 communications link and then manipulated to generate or edit interpolated X-Y or GPS position information. A primary application included is the ability to apply diurnal correction from a base station. This requires secondary base station data file with overlapping date and time information.

Editing functions include shifting lines, changing the direction of lines, appending or cutting lines, deleting or inserting segments of lines or entire lines. Also included are data clean up routines including the ability to remove zero "drop outs", spikes and apply spline high pass or low pass filtering. The program offers a de-striping wizard (heading error correction) and has an interpolator wizard to enable construction of interpolated data files (can make a mag-GPS file from GPS-Time and Mag-Time files).

The resulting data can be plotted a profiles on the PC as a quality control measure and to assure coherence between the original acquisition parameters and the final locations. In addition the program provides simple gridding, contouring and plotting (printing) of the positions, track plots and magnetic contour maps. The data can be exported in formats compatible with Surfer for Windows (*.DAT) or Geosoft OASIS (*XYZ).

Because of the power and complexity of the MagMap2000 program, its operation will not be covered here. Please refer to the MagMap2000 Manual (available on the Magnetometer CD shipped with the magnetometer system) for complete instructions on the use of the program. Also note that the MagMap2000 Manual, the MagMap2000 program and this manual are available on our web site www.geometrics.com under Downloads, FTP, PUB, MAG. We recommend that you regularly visit our site for the latest software upgrades.

Appendix 1: Surveying Principles

This section outlines the principles of performing a magnetic survey for anomaly location. It covers setting up, performing the survey and location of items of interest within the anomalous zones. Regional or geologic surveys for mineral exploration require a different set of procedures and are not covered in this overview. However, many of the guiding principles are identical and review of this section will be helpful.

Guidelines for Small Ground Magnetometer Surveys

The general comments below cover only the site layout and preparations for a survey. The survey objectives, determination of parameters for the instrument data collection and the actual data processing and map preparation are covered elsewhere.

In order to accomplish a successful ground survey magnetometer data acquisition, survey path over the ground and processing of the data into map form must be handled in a precise and accurate manner. Each element is completely interdependent upon the others and if one is compromised in quality or accuracy then all are compromised. During a survey, possibilities for error are numerous and great care and concentration are required to avoid mistakes, some of which may be so serious as to require starting the survey over. The focus should be on completing the survey completely error-free.

Typically, the most difficult surveys are those involving detection of small magnetic targets and the presentation of an accurate 1 or 2 nT contour map. In these cases, the survey must include: a close line spacing (1-2 m) with precise tracking in both the X- and Y- directions; diurnal correction (0.5 nT or better); correction of heading errors from instrument and/or operator; maintaining the sensor a constant distance above the ground; and absolutely no mistakes in procedure and data processing.

Number of People

Under certain conditions, the survey can be laid out and run by one individual; but this is rare and risky. It is far better to have a minimum of two people closely involved and ideally, three or even four people. Not only must the layout and marking of the survey lines be considered but also an individual must be designated to maintain a separate survey log, set up the base station, and operate the portable magnetometer. Note also that the operator doing all of the walking may require relief, for oftentimes the terrain and distance conspire to make his job very grueling.

Survey Efficiency

Speed and cost-efficiency in completing the survey is of course the ideal objective. This does not, however, require the use of innovative short cuts, new gadgetry or excessive manpower, but rather the avoidance of mistakes and errors. To prevent wondering off line even once in the course of a survey, with all of the attendant time spent sorting out and making the corrections, easily justifies a slower but more positive method. Efficiency will only be achieved by avoiding confusion, the correction of errors, and by the use of fail-safe procedures. All of the methods suggested below are simple low tech, and relatively slow, but proven effective. They can easily be improved upon but only at the risk of greater time, survey quality, or greater cost. So in the beginning, keep it as simple as possible.

Layout of the Survey Track

Having determined the optimum line spacing, layout the survey area in a square or rectangular format with the lines running N to S if possible. Use a Theodilite if available, otherwise use a measurement tape (non-stretch) of the required length. Designate one side of the area to be the "baseline" and layout and mark on this line each survey profile. Note that any stakes driven into the ground must be non-magnetic. (Wooden stakes driven into the ground will work well but may not be visible at distance.) If the site will be reoccupied in the future, it may be desirable to drive a one-meter iron rod (re-bar) into the ground at each corner of the survey area as a permanent marker. Since the profile line markers may not be visible at a distance, a method must be found that will allow the Magnetometer operator to locate and follow the line: a light cord or rope stretched on the ground between the beginning and end of each line; a long PVC pipe or other colored marker to be held at the end of each line and then sequentially moved; use of spray paint to mark a series of dashes along the path of each line, etc.

If the terrain is rough or bushy, ground markers along each line will be essential. Otherwise, if the terrain is flat and each end of the line is readily visible, a marker at each end and in the center may suffice. (The operator should have at least two markers to line up on when starting a line.) Whatever method is chosen, it must be completely non-magnetic, positive, easily moved in a coordinated way, and must give the operator a precise direction.

Note that coordination between the people moving the markers is sometimes difficult and frequently a source of error. In addition, if the survey lines are closely spaced, e.g., one- or two-meter separation, the Magnetometer operator may have trouble distinguishing between which marker to head for. The most certain and positive method in all cases is to mark the path by stretching a light string or rope the entire length of the pathway; or, to paint or otherwise mark the ground at short intervals.

If the area to be surveyed is larger than say 100 x 100 meters or difficult to walk through, then the area should be broken up into convenient sub-sections which overlap by at least one profile line. If some sections of line are not passable, then provision should be made for the operator to detour around them but only after establishing a procedure to stop/start (pause) and annotate the data. (This must be foolproof, simple and fully coordinated with the data processing.) Note that the Magnetometer operator must be aware of what line he is on at all times and the line number must agree with the line number recorded in the data. This is once again a frequent source of error and should be double-checked by another person.

In no case should a survey be started until all lines have been laid out and marked, and all aspects of the survey carefully re-checked. A few hours more or less at this stage means very little. What is crucial is to prevent major errors (or even minor ones) that may cost extra days of time and effort.

Diurnal Correction

There are many types of surveys that do not require correction for time varying field errors (diurnal). Generally they involve large magnetic targets such as pipelines and tanks, or coarse line spacing, or where the survey may be accomplished in a very short period of time. In these cases, once it is determined that a severe magnetic storm is not in progress, the survey can proceed without the normal base station correction and with good reliable results.

Note that the high measurement rate of the G-859 allows a rapid walking speed along the profile line. Thus, even large target anomalies are covered within tens of seconds, reducing the potential Diurnal effects.

Surveys that involve very close line spacing, small or subtle targets or where the maximum accuracy is desired require diurnal correction from a base station installed close to the survey area. Ideally, equal sensitivity and measurement rates to the field instrument should be employed in the base station. In general practice, whatever instrument is available is used. In most cases this works well even during periods of relative high field activity.

It should be remembered that "diurnal error" will have the same effects in the mapping process as "location error", and that without correction, low amplitude/high frequency anomalies could appear in the measured data that would seem to be targets but would in fact not be real. In addition, if the survey has been broken up into blocks that are acquired on different days, the blocks will not fit smoothly together unless a diurnal correction is made and their D C level shifted.

There are also other types of local magnetic field disturbances that can seriously effect the map accuracy and quality. These include ground currents and other local AC or DC fields from power lines or urban electric trains or trolleys. Of these, electric trains or trolleys are the more serious as their effects may be large in amplitude and extend for many miles. Usually it is more effective to complete the survey at night when these noise fields are greatly diminished.

Survey Accuracy

Commercial survey specifications may allow an "off line" error of up to ±20% (or more) of the line separation. For a magnetic object having an anomaly extending over several lines, this amount of location error does not prevent the object's detection but does distort the anomaly's shape, its peak-to-peak amplitude and its true location. Large changes in speed along the profile line will have a similar effect but can be prevented by the use of intermediate waypoints. (The worst case condition would be "off line" by +20% in one direction and "off line" by -20% in the opposite direction with each line having a 10% change in speed.) Location errors of this magnitude will not seriously change the overall correctness of the final map, considering that this type of survey is primarily for detection/location. This is not the case, however, if the location errors substantially exceed ±20%, e.g., off by one or more line separations. This amount of error may cause targets of interest to go undetected, or target anomalies to be shifted in location, resulting in, at worst, an erroneous map or at best an untrustworthy one. Careful layout and accurate tracking along the line will avoid these problems.

Survey Credibility

How does a client or survey manager know that a survey has been conducted properly and that the results are correct and believable? He examines the finished contour map for gross errors in data fit, location of target signatures, and overall map quality.

1) Selected anomalies that have been detected are re-acquired to see if they are in the proper location.
2) The raw data are examined to insure that line numbers are correct, data corrections have been properly executed, etc.
3) Selected tests are made on the finished data, e.g., a plot of "stacked profiles" to determine that start/stop points are correct, speed changes are not excessive, there are no data gaps, etc.

Location of Small Objects within Associated Anomalies

When data has been acquired over an area and processed into map form, it is often necessary to reacquire the location of each anomaly and dig to expose the ferrous object. The relocation of the anomaly is relatively simple since the coordinates can be taken directly from the map produced. However, the exact location of the object within the anomaly is often times difficult to identify and the convoluted magnetic field can be very confusing.

The anomaly may be sharp and steep (high frequency) indicating a small object close to the surface. It may be just one peak or it may be multiple peaks depending upon the object's shape, its orientation within the earth's field, and whether the anomaly is largely due to permanent or induced effect. It may appear as a dipole or monopole, and its shape on the map may be further distorted by the distance between profiles, especially if this is large with respect to the object size. Each of these factors will also affect the anomaly signature when the object is much larger in ferrous mass and/or is buried much deeper with the resultant areal coverage of the anomaly much larger (low frequency).

As one sweeps the G-859 sensor over these peaks, it is difficult to conceptually grasp their significance, especially when using the audio output as a reference. To reduce confusion and to provide the basis for a systematic approach, it is very helpful to produce a 3-D map showing each of the peaks and valleys with the perspective of depth. Generally, a high and low pair (monopole) will stand out from the rest of the peaks and if these peaks are relocated using the G-859, the object will be midway between them.

When undertaking this exercise in the field, the audio tone should be turned down or even disregarded with the visual display of the earth's field on the front panel becoming the primary focus. By slowly moving the sensor over the anomalous area, the exact high and low peak can be located and a spot on the ground marked for each. A dipole, in the earth's field inclinations of greater than 60° will have its low North of the high peak, and in horizontal fields (inclination of 0°), the low will be in the center with a high at the North and the South ends. The point midway between high and low will contain the highest gradient and will be directly over the object or very close to it. In those cases where there is only one strong peak, the object will be directly beneath the peak.

For very large anomalies the distance between high and low peaks may be two to ten meters or even greater. To reduce the amount of digging, it is suggested that a short profile be run completely over the anomaly, passing directly over each peak previously located and marked on the ground. Viewing this profile on the G-859 display will allow the estimation of the point of inflection of the curve between the peaks indicating the point of maximum Gradient (which should be directly over the object), and the depth of burial by means of the half width rule. (Refer to chapter V of Applications Manual for Portable Magnetometers.)

Appendix 2: CSAZ

Cesium Sensor Azimuth Program

CSAZ is a program written by Geometrics for users of Cesium magnetometers. The purpose of the program is to determine the proper orientation of the Cesium sensor at various Earth field dip angles (field inclination). AZ stands for azimuth or inclination.

The program is located on the MagMap2000 install disk included with the G-859. Once MagMap2000 is installed, CSAZ will also be installed.

A newly designed CSAZII program is available from our FTP site at

ftp://geom.geometrics.com/pub/mag/Software/csaz2-setup.exe

Please read the manual that is included with the program for complete instructions on how to use the CSAZII program for sensor orientation solutions at various locations on the globe. Note that you should use the "generic" CSAZ mode for G-859 solutions.

Appendix 3: Advanced Information

This information is supplied for those interested in some of the more technical aspects of the G-859. Look in this chapter for some answers to frequently-asked-questions.

Memory Usage

Inside the G-859, readings and positions (Marks and Lines) are simply stored sequentially, with a time stamp. The MagMap2000 program will put the first reading following a mark exactly at that mark. The last reading before a Line event will be placed at that position.

Readings average about 3 bytes each, and positions about 10 bytes. GPS strings average about 30 bytes per reading. There is 1 Mbyte of memory in the standard unit, 2.5 MB in all units with the new CPU board that support 4 com ports. There is no limit to the memory used by each file.

Some memory is wasted by using additional files. Each new file must start on a 64K boundary. An average of 32K will be wasted, then, by opening each additional file.

File Formats

The following information is supplied for those users who wish to perform manipulations on the data beyond that which MagMap2000 is capable of. This section will explain the various file formats used in the data analysis process.

Binary File

This file has the `.BIN` extension, and is a raw dump of the data contained inside the memory of the G-859. This data is not stored in a user readable format. It is compressed in a manner unique to the requirements of the operation of the G-859. Furthermore, each new revision of the G-859 firmware may cause changes in this file format. Do not attempt to modify files of this type.

ASCII File

This file has the `.STN` extension, and is in a user-readable format. This file is created by the program `BINTOASC.EXE`. This program is run with the default parameters from the MagMap2000 program. It may also be run directly from the DOS prompt, and given many options which will adjust the format of the output. Please see the section later in this appendix describing the operation of `BINTOASC`.

The ASCII file contains lines which are a record of events from the perspective of the G-859. Events may be either magnetometer readings, MARK, END LINE, or PAUSE key presses, RS-232 input strings, or field notes. Each event is recorded in the order it was received, and given a time stamp.

Note: The ASCII file lists these events backwards in time, i.e., last-in-first-out.

Each line in the ASCII file starts with a number, referred to as the TYPE in the following discussion. The TYPE indicates what information follows. The table below shows the TYPE for each of the events.

TYPE	Event
0	Magnetometer Reading
3	Position Event
6	Discontinuity Event
9	PAUSE key press
12	UNPAUSE key press
21	RS-232 string

33	Field note

Positions events and discontinuities are caused by MARK or END LINE key presses. Typically, a discontinuity event is associated with the beginning of a line.

The C-program lines which BINTOASC uses to create these files are shown below.

TYPE 0: Magnetometer Readings

```
fprintf(pAscFile, "%-2u %10.3lf %10.3lf %.2d:%.2d:%.2d.%.2d
%.2d/%.2d/%2.d %3u\r\n",
       type,                   // 0 in this case
       reading1,               // reading from sensor 1 (front connector)
       reading2,               // reading from sensor 2 if connected
       hours,                  // time of day
       minutes,
       seconds,
       hundredths,
       month,                  // date
       day,
       year,
       status );               // G-859 internal information.
```

Example:

```
0   49881.953  49874.396 11:02:08.60 06/01/95   0
```

TYPE 3: Position events.

```
fprintf(pAscFile, "%-2u %12.2lf %12.2lf %.2d:%.2d:%.2d.%.2d
%.2d/%.2d/%2.d %10ld %11ld %11ld %3u\r\n",
       type,                   // 3 in this case
       x_position,             // X coordinate
       y_position,             // Y coordinate
       hours,                  // time of day
       minutes,
       seconds,
       hundredths,
       month,                  // date
       day,
       year,
       Number_of_Readings,     // Number of readings since last position or
                               //    discontinuity
       Line,                   // Line number
       Station,                // Mark Number
       Status );               // G-859 internal information.
```

Example: (some blanks omitted to fit onto a single line)

```
3       26.00        0.00 11:02:08.70 06/01/95      168       13       0   5
```

TYPE 6: Discontinuity events.

```
fprintf(pAscFile, "%-2u %12.2lf %12.2lf %.2d:%.2d:%.2d.%.2d
%.2d/%.2d/%2.d %10ld %11ld %11ld %3u %10ld\r\n",
        type,                   // 6 in this case
        x_position,             // X coordinate
        y_position,             // Y coordinate
        hours,                  // time of day
        minutes,
        seconds,
        hundredths,
        month,                  // date
        day,
        year,
        Number_of_Readings,     // Number of readings since last position
        Line,                   // Line number
        Station,                // Mark Number
        Status,                 // G-859 internal information.
        Positions );            // Number of positions since last discontinuity
```

Example: (some blanks omitted to fit onto a single line)

```
6       26.00       0.00 11:02:08.70 06/01/95      168       13       0    5    3
```

TYPE 9: Pause event

```
fprintf(pAscFile, "%-2u %.2d:%.2d:%.2d.%.2d %.2d/%.2d/%2.d\r\n",
        type,                   // 9 in this case
        hours,                  // time of day
        minutes,
        seconds,
        hundredths,
        month,                  // date
        day,
        year ) ;
```

Example:

```
9  18:49:44.90 05/31/95
```

TYPE 12: Unpause event

```
fprintf(pAscFile, "%-2u %.2d:%.2d:%.2d.%.2d %.2d/%.2d/%2.d\r\n",
        type,                   // 12 in this case
        hours,                  // time of day
        minutes,
        seconds,
        hundredths,
        month,                  // date
        day,
        year ) ;
```

Example:

```
12 18:49:44.90 05/31/95
```

TYPE 21: RS-232 event

```
fprintf(pAscFile, "%-2u %s %.2d:%.2d:%.2d.%.2d %.2d/%.2d/%2.2d /4d%
/1d%\r\n",
        type,                   // 21 in this case
        input_string,           // ASCII string received from RS-232
        hours,                  // time of day
        minutes,
        seconds,
        hundredths,
        month,                  // date
        day,
        year
        fine time               //increments of 0.25ms, set to zero every
                                0.1sec
        com ) ;                 //com port from which this data string is
                                received, 0=COM1, 1=COM2, etc.
```

Example:

```
21 $GPGGA,015009.00,3725.9975,N,12209.9992,W,2,4,002.5,00025.1,M,-
028.4,M,001,0000*65 18:49:44.90 05/31/95 0.25 0
```

TYPE 33: Field note

```
fprintf(pAscFile, "%-2u %s %.2d:%.2d:%.2d.%.2d %.2d/%.2d/%2.d\r\n",
        type,                   // 33 in this case
        input_string,           // ASCII string received from RS-232
        hours,                  // time of day
        minutes,
        seconds,
        hundredths,
        month,                  // date
        day,
        year ) ;
```

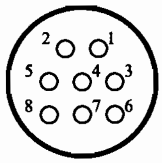
Example:

```
33 Fell down 18:49:44.90 05/31/95
```

I/O Connector Pinout

There are 3 inputs on the I/O connector which simulate END LINE, MARK and ENTER key presses. Momentarily connecting the corresponding pin to pin 4 is equivalent to pressing the key on the keypad:

I/O connector on console:

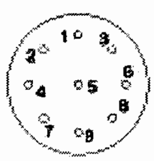


Pin Number	Function
1	Ground
2	RS-232 Receive
3	RS-232 Transmit
4	Ground
5	Mark
6	Audio
7	Line
8	Enter

Power Connector Pinout

If more that COM1 serial port is to be logged, COM2, COM3 and COM4 are presented on the Power Connector.

Power Connector on console:



Pin Number	Function
1	+28V
2	+28V
3	COM4-RXD
4	COM3-RXD
5	COM2-RXD
6	COM3-TXD
7	COM2-TXD
8	GROUND
9	GROUND

Some care needs to be exercised in the design of the external cables. The G859's COM1 connector's ground pin is internally connected to the ground on the power connector. If the external cables also connect COM1 connector's ground to the power connectors ground, a loop will result. This loop will appear asa shorted turn of copper wire to the EM-61. Depending on the cross section of this loop it may effect the data from the EM-61. Also, if a substantial part of the G859's battery current finds its return path through the COM1 cable, a magnetic field will be produced. This magnetic field could effect the data when the G859 is working as a magnetometer.

We have found that building a 100 ohm resistor into the return wire of the COM1 RS-232 cable prevents such problems. Simply omitting the return connection in the COM1 cable will also work, but this can cause confusion when the system is being tested, because two cables must be connected before the COM1 RS-232 connections are complete.

Field Notes

You may extract the field notes into a file in much the same manner as extracting GPS data (se Chapter 9). This is done by using the BINTOASC program with options to tell it to only extract the field notes.

Type the following line at the command prompt:

```
BINTOASC input.bin output.txt -R0 -M0 -D0 -P0 -U0 -S0
```

where

`input` is the name of the file containing the binary downloaded data (you must type the .BIN extension

`output` is the filename you wish for the GPS data (you must give it an extension. The `TXT` extension is a suggestion, however, you may use what you wish.)

`-R0 ...` The options tell the program not to extract everything except the field notes. They are a dash, a letter, and the numeral zero.

You will now have created a file of the field notes, along with some G-859 formatting information. Lines will be as shown below:

```
33 Fell into a hole 10:59:14.80 06/01/95
33 Ran into a tree 11:16:25.40 06/01/95
33 Fell into a hole 12:01:36.80 06/01/95
```

Please contact Geometrics for information regarding availability of programs which automate usage of these features.

EM-61 Data

The data from the Geonics EM-61 consists of two numbers and a gain code. The new G859 software allows this data to be taken from the COM1 serial port and used in place of the magnetometer readings.

Since the numbers from the EM-61 can be both positive and negative, but the G859 software was designed for magnetic fields, which can never be negative, the EM-61 values are adjusted to make them appear in the normal range of magnetic readings. To do this, the numbers are corrected for the gain code, multiplied by 4/125 and then added to 50000.

The readings will span:

50000 - 15.000 * 32768 * 4/125 = 34271.36
50000 + 15.000 * 32767 * 4/125 = 65728.16

To convert these back to normal EM-61 values you simply calculate:

Y = 4(X-50000)/125

Where:
X is the reported value in nT
Y is the correct EM-61 value

MagMap2000 does not yet contain this calculation.

When using the G859 to log EM-61 data you may notice that the displayed numbers move in a more stepwise manner than it does when recording magnetic fields. This is normal. The EM-61 reports a 16 bit integer for its reading. When these are multiplied by the correct factors for each of the gains this causes the resulting values to move in increments as shown below.

15.0000 * 4/125 = 0.480
0.7500 * 4/125 = 0.024
3.7500 * 4/125 = 0.120
0.1875 * 4/125 = 0.006

SYSTEM SPECIFICATIONS

MAGNETOMETER / ELECTRONICS

Operating Principle: Self-oscillating split-beam Cesium Vapor (non-radioactive CS-133).

Operating Range: 18,000 to 95,000 nT (γ)

Operating Zones: For highest signal-to-noise ratio, the sensor long axis should be oriented at 45°, ±30° to the earth's field angle, but operation will continue through 45°, ±35°. Sensor is automatic hemisphere switching.

Sensitivity: 90% of all readings will fall within the following P-P envelopes:

0.03 nT at 0.2 sec cycle rate (SX=0.113nT)
0.02 nT at 0.5 sec cycle rate (SX=0.072nT)
0.01 nT at 1.0 sec cycle rate (SX=0.051nT)

Information Bandwidth: < 0.004 nT (γ)/√Hz RMS

Heading Error: < ± 0.5 nT (γ)

Temperature Drift: 0.05 nT per degree C

Gradient Tolerance: > 500 nT (γ)/inch (>20,000 nT (γ)/meter

Cycle Rate: Variable from 0.2 sec to 1 hr in 0.1 sec steps or by external trigger.

Data Storage: Non-volatile RAM with capacity for 8 hrs of Magnetometer time, event marks, location as GPS at maximum sample rates.

Audio Output:

1. Audio tone of earth's field variation, pitch and volume adjustable. (Search)
2. Audio pulse each 1 second (Pace metronome).
3. Alarm for loss of signal, noise in signal (QC) or low battery.

Data I/O: RS-232 standard bidirectional serial port, selectable continuous real time data transmission via RS-232 to PC. Memory dump transfer time less than 5 min at 115Kbaud transmission rate.

Visual Output: Micro-controller driven, 320 x 200 graphic liquid-crystal display, daylight visible with selectable outputs for:

1. Data display: Up to 5 stacked profiles, real time or review mode. Map of survey grid with zoom functions.
2. All system set-up functions, e.g., memory status, data transfer, sample time.
3. All Survey set-up functions, e.g., survey profile number and direction, station or GPS number,
4. Survey monitoring functions, e.g. total field, noise level, profile number x or xy coordinates.

Internal Clock: Resolution of 0.1 sec, drift: < 1 sec/day

Power: 1. 24 VDC rechargeable gel cell, 6 hrs Magnetometer with GPS. Magnetic effect less than 1 nT (γ) at 3 ft.
2.Internal backup battery for clock and non-volatile RAM.

External power input 12 to 34 VDC, 1 amp on turn-on, 600ma operating in magnetometer mode.

Software: Supplied as part of the basic system for installation in the Geometrics or client-supplied PC, and including functions for:

Operating Software:

1. Survey Modes:
   a. Search
   b. Simple survey, station or continuous
   c. Map survey, station or continuous
   d. Base station
2. Data acquisition/display:
   a. Acquire and store data and survey functions.
   b. Display profiles, total field to 0.1 nT resolution,, survey/map parameters and diagnostics.
   C. Map display showing location of all readings.

PC Support Software:

1. Data transfer and corrections:
   a. Transfer of data from the field Magnetometer, GPS, or Base station to the PC.
   b. Diurnal correction using base station data.
   c. Processing the corrected data into ASCII values of X-Y-Z for the magnetometer
2. Optional bundled "Surfer for Windows" by Golden. Provides data presentation/plotting into a contour map or 3D isomagnetic map with Text annotation and color blends.

MECHANICAL

Sensor: 2-3/8" dia., 6-3/4" long, 12 ounces 6 cm x 15 cm, 340 g

Console: 6" W, 3" H, 11" L, 3.5 lbs. (15 cm x 8 cm x 28 cm, 1.6 kg), attaches to harness. Magnetic effect less than 1 nT (γ) at 3 ft

Battery: 3" H, 5" W, 8" L, 3.5 lbs (8 cm x 13 cm x 20 cm, 1.6 kg) attaches to harness.

Backpack specs ?

ENVIRONMENTAL

Operating Temperature: -15°C to +50°C (-13°F to + 122°F)

Storage Temperature: -35°C to + 60°C (-30°F to + 140°F)

Water Tight: To 1 ft (0.3 m) depth for 10 seconds.

Shock: Drop 3 ft on a hard surface without damage

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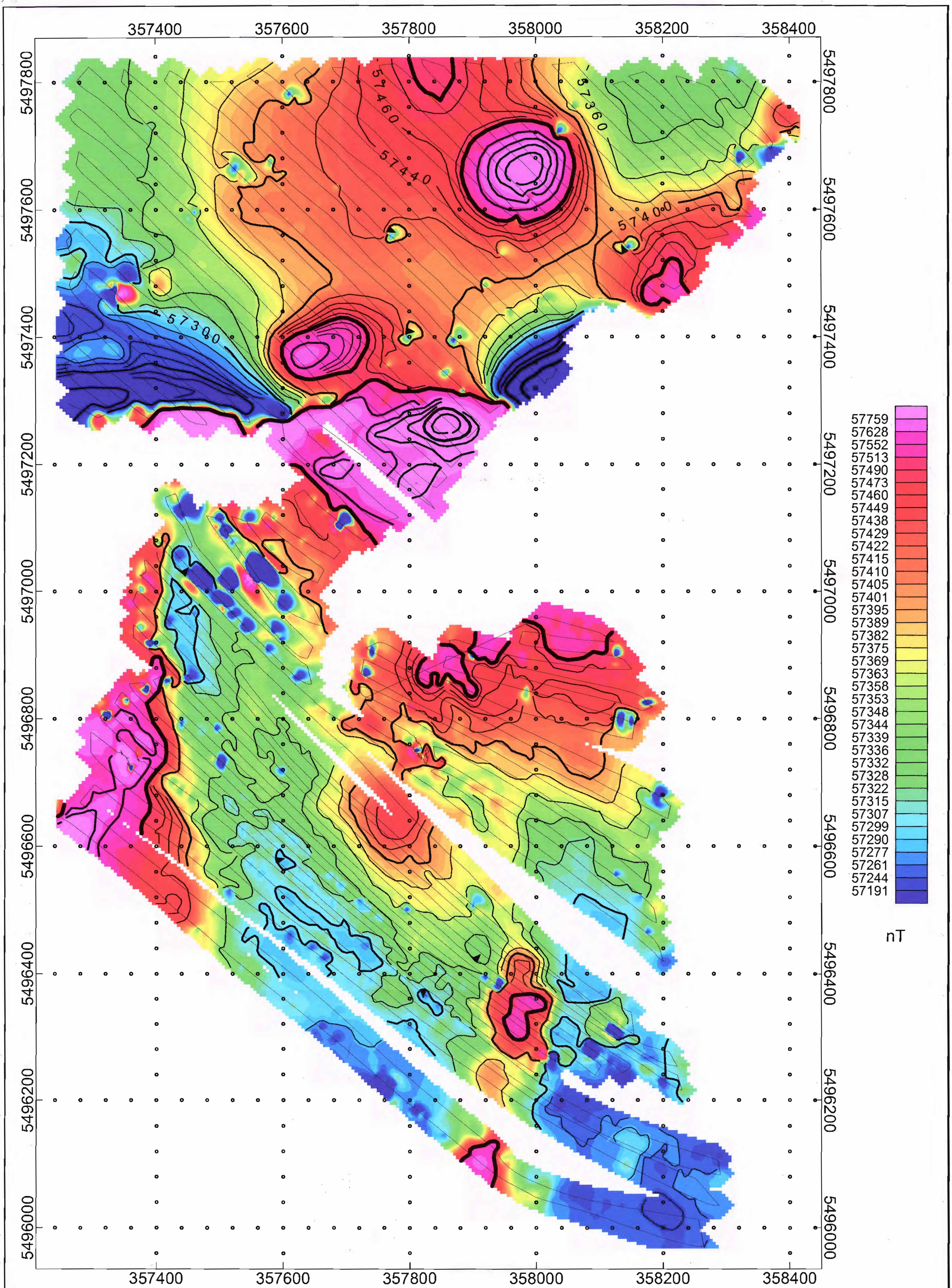
Appendix C

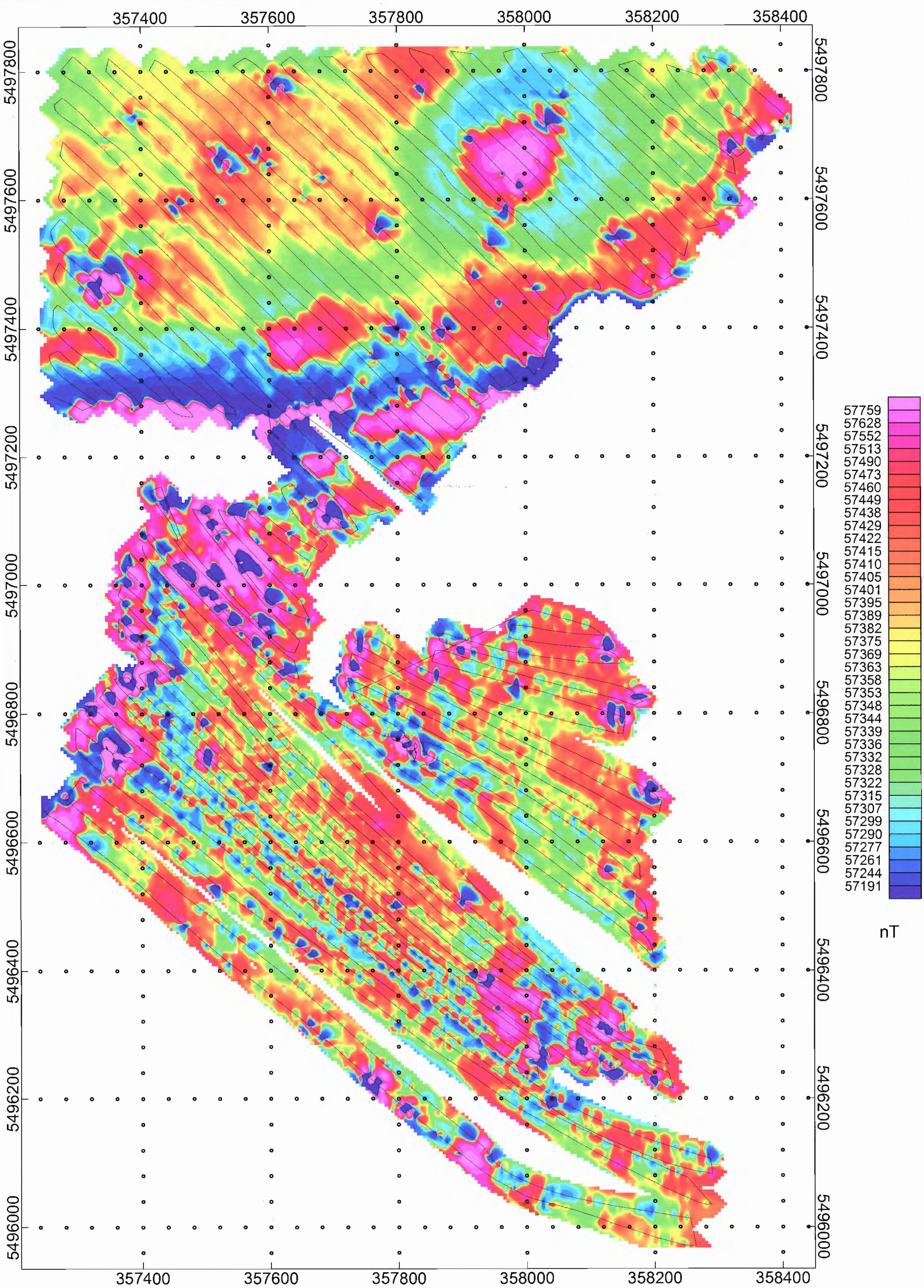
Geophysical Maps (TMI and 1VD)



Total Magnetic Intensity Grid

10nT contour interval

March 04, 2010



First Vertical Derivative Grid

March 04, 2010

100 0 100 200 300

(meters)

NAD83 / UTM zone 15N