9229-C4-7E

1988-89 GEOPHYSICAL REPORT
PROGRAM 9229-C4-3E
PROGRAM 9229-C4-4E
PROGRAM 9229-C4-5E
PROGRAM 9229-C4-7E

Prepared by:

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INTRODUCTION

The Chevron-Fort Good Hope Joint Venture land parcel encompasses an area of approximately one million acres in the Mackenzie Valley between Fort Good Hope and Norman Wells (Figure 1). The joint venture agreement required Chevron to establish a community owned gravity and survey company in Fort Good Hope. This agreement also committed Chevron to contract the gravity and survey company, incorporated as Star Tech Incorporated Ltd., to collect about 8 000 gravity stations on the Fort Good Hope landblock. These gravity data would enhance Chevron's understanding of the regional geology and provide Star Tech with an initial income source and permanent asset base (ownership of the gravity data). This report will document training, aerial photography, gravity data acquisition, processing and interpretation associated with these gravity surveys.

LIST OF FIGURES AND ENCLOSURES

PROGRAM DESCRIPTIONS

Program Numbers:	9229-C4-3E, 9229-C4-4E, 9229-C4-5E, 9229-C4-7E
Type of Survey:	Gravity
Period of Data Acquisition:	87-12-01 to 88-09-30
	88-11-.4 to 89-04-06
Survey Area:	65° 15' N to 66° 30' N
	128° 30' W to 130° 15' W
	(Figures 1 and 2)
Operator:	Chevron Canada Resources
Contractors:	Star Tech Incorporated Ltd.
	(gravity data acquisition and ownership of data)
	Chevron Exploration and Production Services (gravity data reductions)
	MWH Geo-Surveys Ltd. (Consultants)
	Airborne Resource Developments (Consultants)
	Walker, Jess and Associates (Consultants)

Chevron Canada Resources and Star Tech Incorporated Ltd. conducted gravity surveys in 1987-88 and 1988-89 under three geophysical program numbers. Listed below is the work performed with each program number.

9229-C4-3E Training (installation of photo-targets), aerial photography and gravity data acquisition prior to 1987-12-31.

9229-C4-4E Gravity data acquisition on landblock from 1988-01-01 to 1988-04-15.

9229-C4-5E Training (combined GPS/gravity survey techniques on landblock), Manitou Lake and Mackenzie Mountains gravity surveys from 1988-05-17 to 1988-09-20.

9229-C4-E7 Gravity acquisition on the landblock from 1988-11-24 to 1989-04-06.

Although a previously submitted report covered the gravity programs up to April 1988, this report will cover this older data plus the data acquired in the 1988-89 season. It was felt that this would provide a more complete report as much of the 1988-89 data infills the previous data and forms a complete data set. The training aspects will not be covered here in detail as they were completed in 1988 and are described in the previous report. The aerial photography will be repeated from the previous report as it involves data acquisition and processing in subsequent years.

GRAVITY DATA ACQUISITION - PROGRAMS 3E, 4E, 5E, 7E

PRODUCTION SUMMARY

Dates	Description
1987-08-10 to 1987-09-30	196 gravity base stations established on 196 photo targets distributed over landblock (program 3E).
1987-11-30 to 1988-04-15	4 140 gravity stations acquired on seismic shot points (programs 3E, 4E). This interval was every 120 m in Zone II and 144 m in Zones I, III and IV (Figure 2).
1987-12-01 to 1988-01-19	634 gravity stations acquired in Zone II at a 750 m interval (programs 3E, 4E).
1988-01-20 to 1983-04-15	2 239 gravity stations acquired in Zone I at 750 m and 250 m intervals. 201 gravity stations acquired in Zone III at a 750 m interval (program 4E).
1988-04-15	128 gravity stations acquired in a 3 km x 2 km area centred at 65° 45' N - 129° 08' W (program 4E).
1988-06-27 to 1988-07-12	993 gravity stations acquired in Zone IV at a 750 m interval (program 5E).
1988-07-03 to 1988-07-14	107 gravity stations acquired in Zone I at a 250 m interval (program 5E).
1988-09-07 to 1988-09-20	124 gravity stations acquired in Zone I at a 250 m interval (program 5E).

Dates	Description
1988-08-05 to 1988-09-01	706 gravity stations acquired 15 km NE of Zone I at Manitou Lake at a 100 mi interval (program 5E).
1988-11-24 to 1989-04-06	7 186 gravity stations acquired on seismic shot points. 2 499 gravity stations acquired regionally at approximately 750 m intervals (program 7E).

The total number of gravity stations acquired is approximately 18 952. This total includes gravity stations that were collected outside but adjacent to the landblock. These stations were acquired to provide peripheral data control around the landblock.

BASE OF OPERATIONS

Five different operating bases were employed for gravity data acquisition. These were Fort Good Hope, Mountain River Base Camp, the drill camp and two remote base camps located in Zone I.

MOBILIZATION

Mobilization to the 200 gravity base stations, the 124 stations acquired in 1988-09, the 107 stations acquired in 1988-07 and the 993 stations acquired in 1988-06 was by helicopter. Transportation to collect all other gravity stations on and off seismic lines was by snowmobile.

PERSONNEL

The average number of personnel including office staff was 13 people per day. This total included 9 field and 2 office workers who were native residents of Fort Good Hope. There were also 2 non-native office and field supervisors.

EQUIPMENT

5 La Coste and Romberg Model G gravity meters
5 Trimble 4000 SX differential GPS receivers - single frequency
1 AIR-HB-1A hand-held barometers
1 AIR-AR-DB-lA winterized base barometer with CR10 logger
1 AIR-AR-DB-lA base barometer with CR10 logger
1 TANS GPS code receiver

AERIAL PHOTOGRAPHY AND PHOTOGRAMMETRY

The photogrammetric positioning technique requires an even distribution of photo-identifiable first order benchmarks and aerial photography at an appropriate scale to achieve desired accuracies. The photo-targets provide spatial control to obtain coordinates for other locations, such as gravity stations, marked on the aerial photographs. 196 aerial photo-targets were positioned throughout the landblock on a semi-regular grid of five kilometres (Figure 2). Horizontal and vertical coordinates for each photo-target benchmark were determined using a constellation of navigation satellites called the GLOBAL POSITIONING SYSTEM (GPS) and differential GPS receivers.

Aerial photography was flown at an altitude of 10 000 feet producing colour photographs at a scale of 1:20 000. Each gravity station was marked with a small hole punctured in the photo. All photographs were then issued to a photogrammetrist who determined the horizontal and vertical coordinates of each gravity station by using the GPS surveyed photo-targets as a network of spatial control.

The photogrammetric technique also allows a digital elevation model (DEM) to be constructed from the 1:20 000 colour photographs. These data were acquired and provided a horizontal sampling of the topography every 100 m or less. The DEM permitted the calculation of partial inner, and complete outer terrain corrections to be computed for all gravity data.

SURVEYING AND POSITIONING

Coordinates and elevations for all gravity stations coincident with seismic shot points were determined using conventional transit survey methods. Positions for the 196 gravity base stations and the 124 stations acquired in 1988-09 were determined by differential Global Positioning System (GPS). Horizontal and vertical coordinates for all other gravity stations were acquired by photogrammetric techniques. Barometric elevations were also measured for gravity stations positioned with photogrammetry. No permanent structures were utilized to mark the gravity stations. This does not include the 200 base stations that were situated on semi-permanent photo identifiable targets.

GLOBAL POSITIONING SYSTEM

196 Gravity base stations/Survey benchmarks.

a) spatial accuracy = 0.1 m

b) repeatability < 0.1 m

124 Gravity stations acquired in 1988-09.

a) spatial accuracy = 0.5 m

b) repeatability < 0.5 m

CONVENTIONAL SURVEY SYSTEM

11 326 Gravity stations acquired on seismic shot points.

128 Gravity stations acquired at 65° 45' N - 129° 08' W.

706 Gravity stations acquired at Manitou Lake (66° 20' N - 129° 00' W)

a) accuracy = 0.5 m

PHOTOGRAMMETRIC SURVEY TECHNIQUE

6 472 Gravity stations located on 1:20 000 colour aerial photography.

a) vertical accuracy = 0.5 m

b) horizontal accuracy = 20 m

GRAVITY DATA REDUCTIONS

All gravity data have been reduced with a model of variable Bouguer densities ranging from 2.3 g/cc to 2.7 g/cc corresponding to an effective average density of the local surface geology. Inner terrain corrections were computed in the field using Hammer charts but were not incorporated into the Bouguer values because they were deemed to be consistently inaccurate. Outer terrain corrections were computed using the variable density model, the digital elevation data within the landblock, and 1:50 000 digitized topographic maps around the periphery of the landblock. These corrections will be negligible for all data in Zones I and III due to small topographic variations.

DATA EDITING

Numerous errors in the form of meter reading, elevation and location were found in the recorded data. These errors were corrected where possible. If the source of errors could not be determined, the stations were deleted from the data set. 995 stations had to be deleted leaving a final data set of 17 957 gravity stations.

INTERPRETATION

FORMATION DENSITIES

Stratigraphy	Density (g/cc)
Cretaceous	2.30
Devonian - Imperial	2.60
- Kee Scarp	2.70
- Hare Indian	2.67
- Nahanni	2.67

MAPS

The enclosed Bouguer Anomaly Map includes data acquired since the Chevron-Fort Good Hope Agreement was consummated in June 1987 and federal government data.

REGIONAL GEOLOGY

The regional stratigraphy near Fort Good Hope consists of Proterozoic and Phanerozoic rock sequences. The Phanerozoic section overlies an extremely thick interval of Proterozoic rocks. Laramide orogenic episodes have deformed the Phanerozoic rock sequences in the southern one-third of the landblock as evidenced by the Mackenzie Mountains, East and West Mountains and the Imperial Hills. The Laramide orogeny has sufficiently dissipated northward such that Phanerozoic sediments in the northern two-thirds of the landblock are essentially undisturbed. Crystalline or metamorphosed Archean cratonic rocks would underlie the thick Proterozoic strata if they exist at all. Lower Cretaceous rocks overlie the Pre-Cretaceous Unconformity with Upper and Lower Cretaceous sequences thickening from northeast to southwest.

REGIONAL GRAVITY

The Bouguer Anomaly Map portrays the strike of the gravity field as almost linear in a northwest direction and dipping monotonically toward the southwest across the northern half of the landblock. Three important geological facts explain this systematic behavior of the gravity field. First, the lack of significant Laramide deformation to the Phanerozoic section has left these rock units undisturbed. Therefore, no large density contrasts exist in the shallow subsurface. Second, the presence of a Proterozoic basement rather than an Archean complex has precluded the potential for large lateral density contrasts that can frequently be associated with undisturbed Archean rock assemblages. Finally, the gradational thickening of low density Cretaceous sediments towards the southwest accounts for the decreasing Bouguer values in the same direction.

In the southern one-half of the map area the effects of the Laramide orogeny are manifested by three substantial positive gravity anomalies. The positive features present along the southern and western boundaries of Zone IV are caused by thrusted high density Paleozoic carbonates forming the Mackenzie Mountains. Another positive anomaly flanks the eastern boundary of Zone IV and is caused by similar thrusting expressed as the Imperial Anticline or Imperial Hills. Separating these two gravity highs is an east-west gravity low called the Imperial Syncline where low density Cretaceous sediments generate a negative density contrast against adjacent Devonian carbonates on the north and south. Finally, the northeasterly orientated gravity high located in the central part of Zone II overlies the thrusted subsurface Whirlpool Anticline and the surficial West and East Mountains. The same geologic rationale explains this positive gravity feature as the previous two associated with the Mackenzie Mountains and Imperial Anticline.

ISOLATED ANOMALIES

The local gravity which located at 65° 46' N - 129° 08' W overlies thrusted Phanerozoic section similar to the Whirlpool Anticline. Again, the positive density anomaly results from higher density Paleozoic units creating a positive density contrast with adjacent lower density Cretaceous elastics.

A northeasterly warp in the Bouguer contours in the north-central portion of Zone I produces a negative Bouguer anomaly. Depth estimates suggest that this feature is sourced at approximately 3 000 m which pertains to the Proterozoic or lower Cambrian. Therefore, two explanations could satisfy the observed effect of the gravity field at surface. First, the extensional phase of the Racklan orogeny(1.1 b.y.) could have produced a local trough that was infilled by lower density Proterozoic sediments. Second, differential subsidence or sustained tectonism in a Proterozoic trough during the Cambrian could result in a Cambrian Basin being filled with lower density Cambrian clastics. Each of these two episodes are plausible explanations for the measured polarity and calculated depth.

Numerous high frequency gravity anomalies are present where station locations are close enough to adequately sample local density variations in the near surface. Most of these sharp features are negatively polarized and induced by paleo-river channels in pre and post glaciation. Old river channels are usually deposited with unconsolidated sands and silts that possess lower average densities than the incised bedrock or compacted glacial till resulting in a negative gravitational response.

Depth to source estimates on the elongated NW-SE gravity high at 65° 54' N - 129° 22' W give an approximate depth of 400 m. This indicates that the anomaly is caused by a density variation within the Cretaceous sediments.

The gravity high cutting north-south through the mountains in Zone IV at about 129° 13' coincides with a topographic valley. All the rivers in this area run towards the northern apex of this gravity high indicating that this point may have been a regional topographic low for an extended period. It is possible that the upper crust of this location has not attained isostatic balance. The gravity high could also be the result of incorrect Bouguer and terrain corrections for the stations in the valley.

INDEX MAP

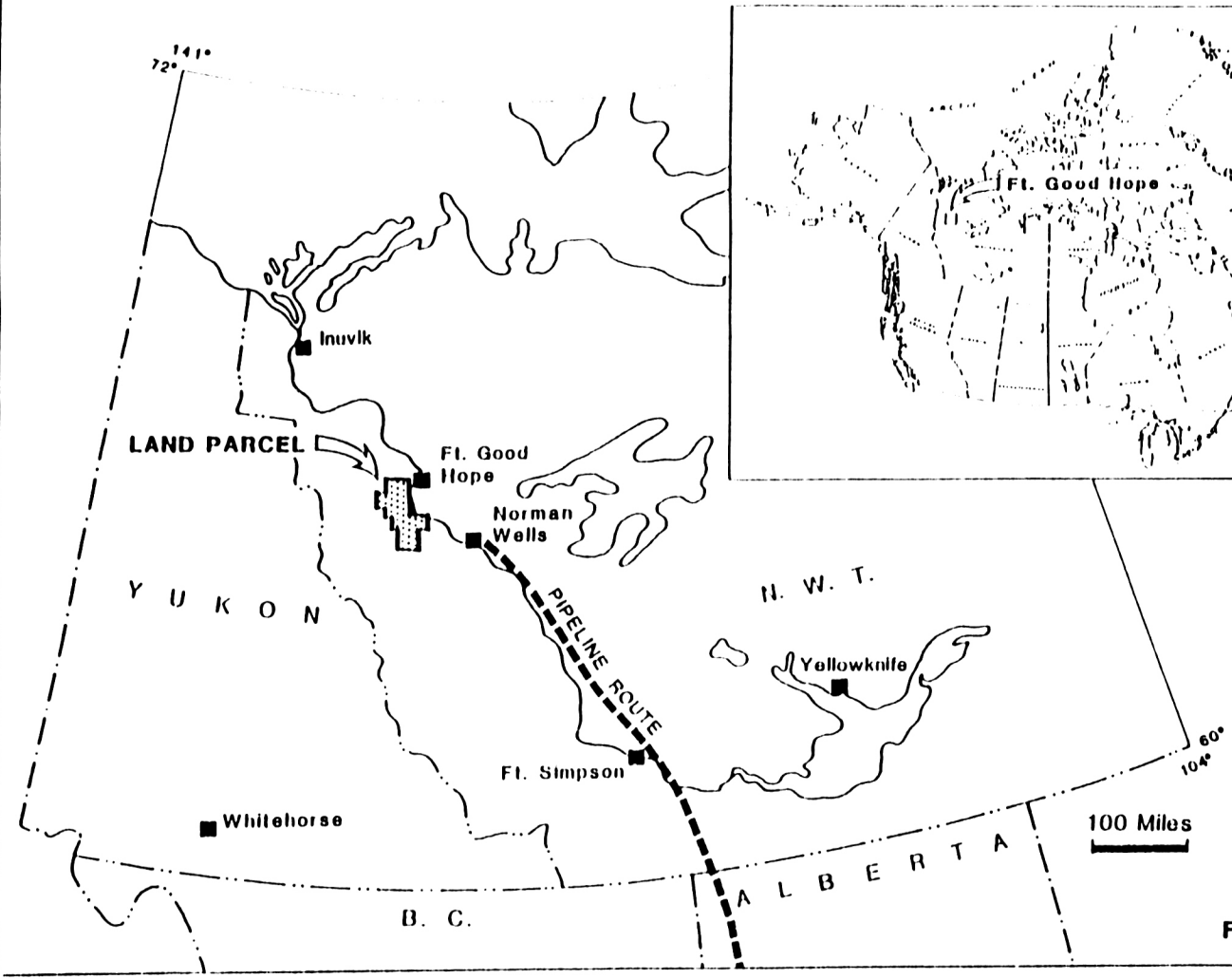

FIGURE 1

FLIGHT LINE & PHOTO TARGET LAYOUT MAP

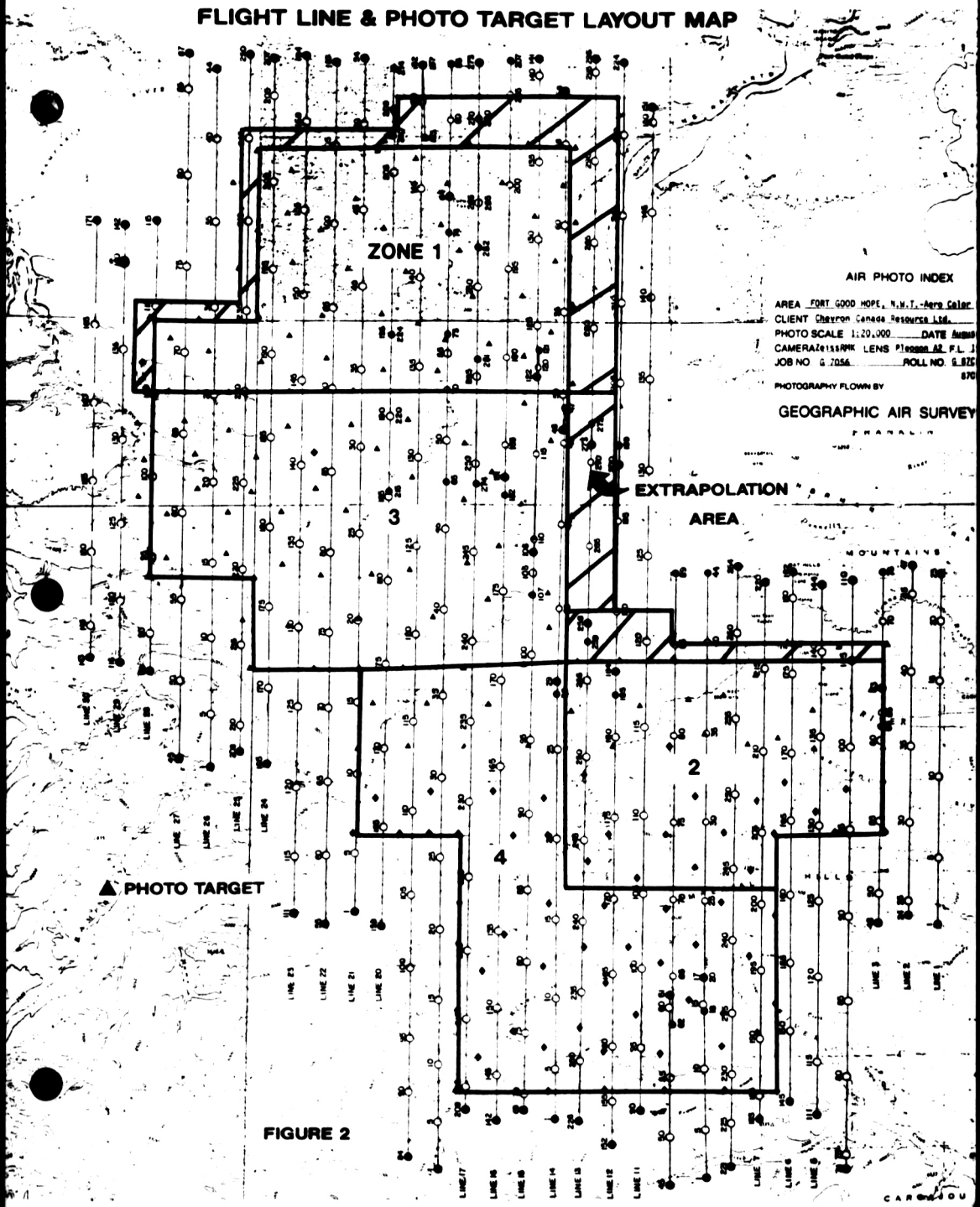

FIGURE 2

PROGRAM NUMBER 9229-C4-7E AREA FORT GOOD HOPE

YEAR 1988/89 E.A. 322

FILED UNDER: SAME (REPORT COVERS 9229-C4-3E, 9229-C4-4E, 9229-C4-5E)

REPORTS

OPERATIONS REPORT: NUMBER 1

INTERPRETATION REPORT: NUMBER ____

MAPS
SHOTPOINT MAPS NUMBER —

INTERPRETATION NUMBER 2

- BOUGUER GRAVITY + TERRAIN CORRECTION VARIABLE DENSITY MODEL

- BOUGUER GRAVITY

OTHER NUMBER —

SECTIONS NUMBER —

PROJECT ACTION SHEET

RESOURCE EVALUATION BRANCH

PROJECT NUMBER: 9229-C4-7E

COMPANY: CHEVRON

REPORT TITLE: 1988/89 GEOPHYSICAL REPORT

The following action has been taken:

Receipt acknowledged: JUNE 7/90

Reports and maps date-stamped: ✓

Reports for review list edited: ✓

Inventory sheet made: ✓

Mylar: NO

REVIEW AND APPROVAL MADE BY: L. Richards Oct/90

****RETURN APPROVED REPORTS TO MIKE McLINTON******

COMMENTS: 3 COPIES of REPORTS AND MAPS.

* THIS REPORT ALSO DISCUSSES SOME of 9229-C4-3E/4E/5E.