FIELD PROGRAM AND PRELIMINARY RESULTS OF THE PILLAR RECOVERY PROJECT AT NANISIVIK MINES LTD., NORTHWEST TERRITORIES (MAY 1989)

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SUMMARY

At Nanisivik Mine about 11% of the ore is contained in unconfined pillars. Roof inspections, dilatometer tests, rock sampling and ground stress determinations were carried out as an initial step to assess present and future excavation stability. In addition, ground movement monitors and CANMET strain monitors were installed to determine ground reactions during pillar recovery. All elements of the program were successfully completed. However, only a 25% success rate was realized in carrying out stress determinations in pillar 37.10/2, because of ice-filled vughs in the ore. In situ stress determinations in the fine grained dolomite of the South abutment were successfully carried out with South African triaxial strain cells using Hoettinger 60 cement glued at -15°C. The maximum compressive stress is NE-SW/sub-horizontal with a magnitude of 3.9 to 6.1 MPa.

Based on the above results and the determination of laboratory rock strength and deformation parameters, a numerical model will be developed to predict ground reactions to selective pillar removal.

A more detailed report on field and laboratory investigations is being prepared.

KEYWORDS: Ground stress, roof stability, arctic, ground behaviour, monitoring.

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INTRODUCTION

Funding under the NWT Mineral Development Agreement, has been made available to Strathcona Mineral Services Ltd., Toronto, to study the potential of increased extraction at the Nanisivik Mine, NWT. This lead/zinc mine is located at the northern tip of Baffin Island at about 73° N latitude in permafrost. Nanisivik Mines subcontracted the rock mechanics program of the study to the Canadian Mine Technology Laboratory of MRL, CANMET, Ottawa. The program has four elements: field investigations, laboratory testing, analysis of excavation stability and monitoring.

In the following, preliminary results are provided for field investigations carried out in the period May 4-18, 1989. Some of the procedures had never been tried before in permafrost.

Access to the 50-125 m wide and about 2750 m long sub-horizontal lead/zinc orebody is through two portals cut into the mountain side. Maximum cover for the 5 to 20 m high orebody is about 130 m.

FIELD PROGRAM

For the field program it was assumed that the minimum cover for the mine would be 20 m, that no major geological discontinuities or weak materials exist in the roof and that pillar recovery would start from the east end of the mine and proceed towards the west end. The following program, therefore, was concentrated in the vicinity of the east portal.

Roof inspection and roof monitoring:

Ten vertical BQ holes were diamond drilled from surface or from underground to intersect the roof as shown in Figure 1 for colour TV bore hole inspection. All of the holes are to be fitted with Ground Movement Monitors (GMM).

All readings of the GMM stations will be carried out from site D (Fig.1). Electronic cables will be fed through 3/8 in. ID or larger soft plastic or rubber tubing along the roof and down the wall to site D. 1000 m of electronic cable had been ordered for installation of the GMM units. At the mine site about 850 m of tubing is available, mine staff will fasten the tubing to the roof and wall as a conduit for the electronic cables.

The core from the BQ holes will be logged for rock type and geological discontinuities. An RQD value is to determined for each hole and the core is to be kept for inspection.

Stress determinations in pillars and abutments (side walls):

It was planned to drill 3 Ex holes (horizontal/+ 5 degrees) for the installation of South African (CSIR) triaxial strain cells or USBM meters and to overcore them with a six in. diameter bit. Maximum length 35 ft. The six in. holes will be used afterwards for CANMET strain monitors and data loggers. Locations are in pillars P38.09/1 and P37.10/2 and site A(Fig.2). The latter will be confirmed after site inspection. If triaxial strain cells are not successful, a site near 15 S will be selected to drill three Ex holes with six inch overcoring for ground stress tensor determination using a USBM meter.

In situ deformation modulus:

Four horizontal NQ diameter holes (at sites B, C (6m long) and in pillars P37.09/3 (Fig.3) and P37.09/1 (Fig.4)) are to be drilled for use of the Probex dilatometer and for strain change monitoring during pillar recovery.

Pillar monitoring:

Six in. diameter holes in pillars P38.09/1 and P37.10/2, and NQ holes at sites B and C and pillar P37.09/3, will be fitted with CANMET strain monitors and data loggers.

Two parallel Ex diameter diamond drilled horizontal holes have been drilled at right angles to the ore body axis through pillars P37.09/3 and P37.11/2. They are to be fitted with ground movement monitors to monitor load transfer to the pillars.

SUMMARY OF DIAMOND DRILLING

Drilling before May 4, 1989:

Ten vertical BQ holes from surface (Fig.1),
Two NQ holes + 5 degrees, 6 m long at sites B and C (Fig.3),
Two NQ holes + 5 degrees through pillars P37.09/3 (Fig.2) and P37.09/1 (Fig.4),
Four Ex holes + 5 degrees through pillars P37.09/3 and P37.11/2 (Fig.3),
Three meters of six in. diameter hole at + 5 degrees into pillar, P37.10/2 (Fig.3). Leave drill set up to continue drilling for ground stress determination in May 1989.

Drilling after May 4, 1989:

Continue drilling of horizontal six in. hole in pillar P37.10/2,
Drill Ex and six in. diameter horizontal hole in pillar P38.09/1,
Drill Ex and six in. diameter horizontal hole at location A,
Drill three Ex and six in. diameter holes for ground stress tensor in area 15 S (optional).

All core from diamond drilling is to be logged for rock type and geological discontinuities. Core samples will be selected for laboratory testing.

INSTALLATIONS

Install six ground movement monitors in BX holes:

M1, M2, M5, M6, M7, M9 - mechanical anchors and 10 ft rods with 5/8 in. left hand thread are required at mine site.

Install four ground movement monitors in EX holes of pillars P37.09/3 and P37.11/2.

Carry out in situ tests with Probex dilatometer in NQ holes (sites B and C, pillar P37.11/2).

Carry out stress determinations with six in. overcoring in pillars P37.10/2, P38.09/1, site A and possibly at a site in area 15 S.

Install one vertical and one horizontal CANMET strain monitor in six in. diameter drill hole of pillars P38.09/1 and P37.10/2 with one data logger for each pillar.

Install one vertical and one horizontal CANMET strain monitor in NQ holes at sites B, C and in Pillar P37.09/3 with data loggers.

Installation of two CANMET strain monitors in NQ hole of pillar P37.09/1 is optional.

PRELIMINARY RESULTS (May 18, 1989)

TV Borehole Inspections:

The colour TV borehole examination was carried out from the roof line for 6 m (20 ft) into the roof. Access to the roof was provided with a giraffe which had a basket big enough for two people, a 13 in. TV monitor, a VCR, and the Welch Allyn Video Probe 2000 with a 15 m cable. All inspections were recorded on video tape.

Seven holes were inspected (M1, M3, M5, M6, M8, M9, M10). Holes M2, M4, M7 were not accessible. All holes showed the roof in good condition with some minor horizontal cracking close to the roof line. Holes close to the East portal showed occasional horizontal fractures at a depth of 5 to 6 m above the roof line.

In Situ Dilatometer Tests:

Three dilatometer tests were carried out in sulfide ore in hole NQ 4 at site C which provided an elastic modulus of 20.0 to 22.6 GPa (2.9 - 3.3 x 10^6 psi). One dilatometer test in fine-grained dolomite in the South abutment (site B, hole NQ3) provided an elastic modulus of 44.8 GPa (6.5 x 10^6 psi). Holes NQ1 and NQ2 in pillars P37.09/3 and P37.09/1 respectively will be fitted with 3-inch CANMET strain monitors at a later date. All the future data loggers will be fitted with arctic battery packs.

Ground Stress Determinations:

Four ground stress determinations were carried out in pillar P37.10/2. The first test with a CSIR triaxial strain cell failed to bond with Philips strain gauge cement at -18°C. Three USBM meter tests were then carried out, one was successfull. The secondary stresses determined at 4.4m from the collar were as follows (E = 20 GPa): σ_1 = 8.5 MPa, σ_2 = -1.8 MPa with σ_1 dipping 65° South.

Stress determinations in the South abutment near site D were 100% successful in the finegrained dolomite: Four USBM meter tests carried out at 3.5 to 6.3 m from the collar indicated the following stress conditions (E = 44.8 GPa): σ_1 = 4.7 - 7.8 MPa, σ_2 = 0.3 - 2.5 MPa, σ_1 dipping 45 - 73° West.

Two triaxial tests with CSIR strain cells, bonded successfully with Hoettinger x 60 cement and provided the following principal stresses (Elastic modulus = 44.8 GPa, Poisson's ratio = 0.3):

Depth	σ_1 (MPa/Dip direction/Dip)		σ_2 (MPa/Dd/Dip)		σ_3 (MPa/Dd/Dip)	
3.4 m	6.1	045°/6°	1.9	304°/60°	1.4	138°/30°
6.75 m	3.9	053°/13°	1.5	278°/71°	0.8	146°/12°

The vertical component was 1.8 MPa at 3.40 m and 1.6 MPa at 6.75 m from the collar.

CANMET Strain Monitors:

Four CANMET strain monitors were installed in the six inch diameter holes after strain recovery measurements and connected to RBR data loggers.

Pillar 37.10/2 - Sulfide
Ring 122, vertical at 15 ft from collar, 13:30 May 11, 875Hz (outside hole: 761 Hz)
Ring 121, horizontal at 14.45 ft, 15:00, May 11, 1090 Hz (outside hole: 764 Hz)

South Abutment (site D) - Finegrained Dolomite
Ring 123, vertical at 15 ft from collar, May 17, 795 Hz (outside hole: 737 Hz)
Ring 124, horizontal at 14.5 ft, May 17, 887 Hz (outside hole: 754 Hz)

Ground Movement Monitors (GMM):

Two ground movement monitors were installed in horizontal Ex holes drilled into pillar P37.11/2 to record pillar expansion during load transfer.

Ex 1 at 8 ft showed a resistance of 8.4 Ω between the red and black lead wires.

Ex 2 at 14 ft showed a resistance 6.72 Ω between the red and black lead wire.

Expansion will increase the resistance (Ω) reading.

It is intended that GMM units be installed in all of the BQ holes drilled into the roof with anchors at 3 m (10 ft). Preparation of anchors, and steel rods and the installation and electrical wiring of the GMM units at site D will be done by mine staff. Additional GMM units have been ordered for this purpose.

Table 1: Calibration of ground movement monitor 9-33

April 3, 1989

Resistance(kΩ)	/Deformation(0.001 in.)	Resistance(kΩ)	Deformation(0.001 in.)
0.000	0	2.42	550
0.000	30	2.92	600
0.073	32	3.42	700
0.086	33	3.92	800
0.103	34	4.42	900
0.114	35	4.92	1000
0.147	40	5.92	1200
0.213	50	6.98	1400
0.271	60	7.86	1600
0.377	80	8.84	1800
0.475	100	9.83	2000
0.562	120	10.80	2200
0.659	140	11.80	2400
0.769	160	12.79	2600
0.856	180	13.81	2800
0.944	200	14.83	3000
0.050	220	15.81	3200
0.150	240	16.78	3400
0.197	250	17.78	3600
0.438	300	18.75	3800
0.931	400	19.48	4000

1. Hookup to red and green, fully extended 0.000 kΩ

2. Supplied by FREMA R & D services, P.O. Box 51
   Garson, Ontario, POM 1V0 - Telephone (705) 693-2484

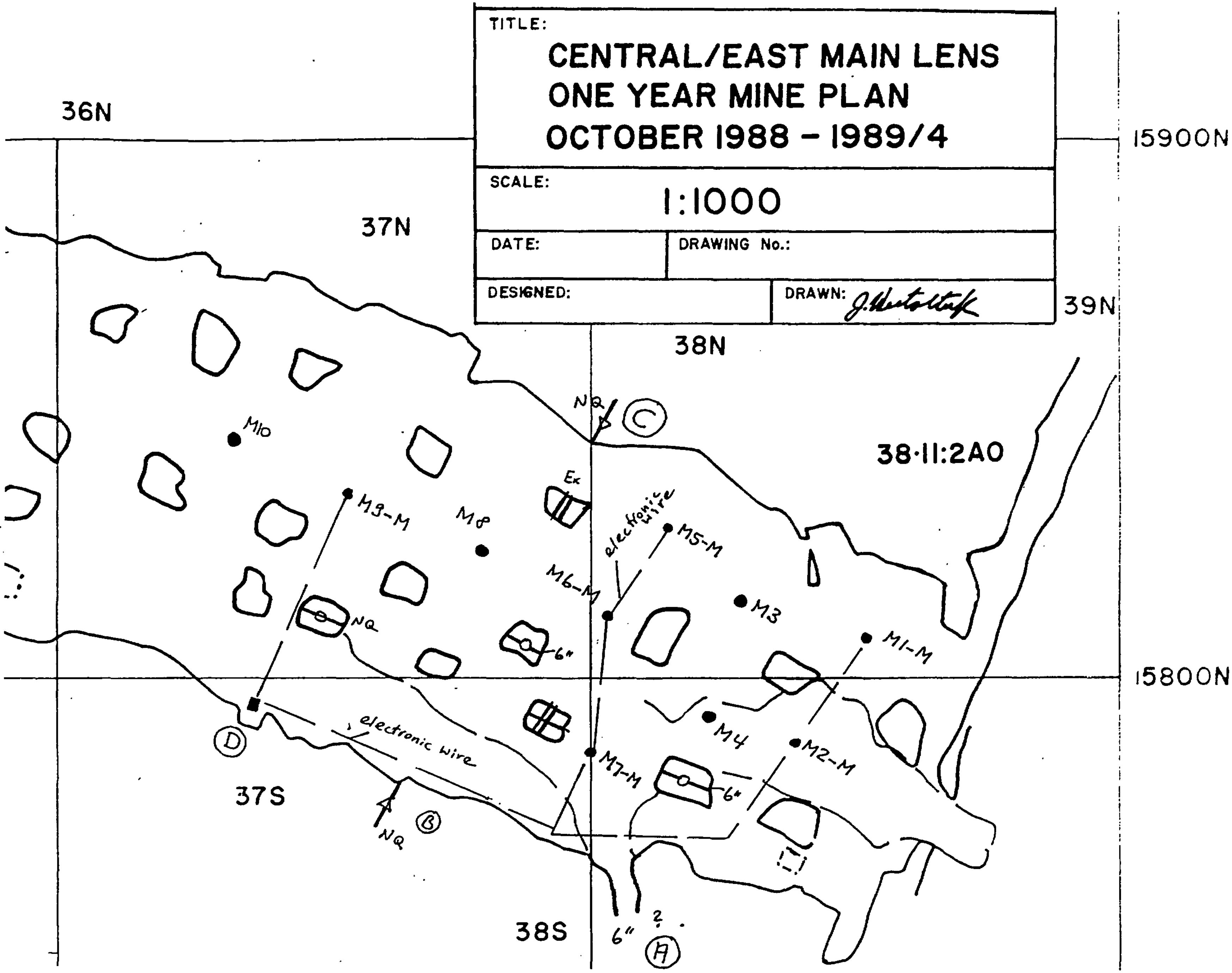

Fig. 1 Overview of test sites at Nanisivik Mines Ltd.

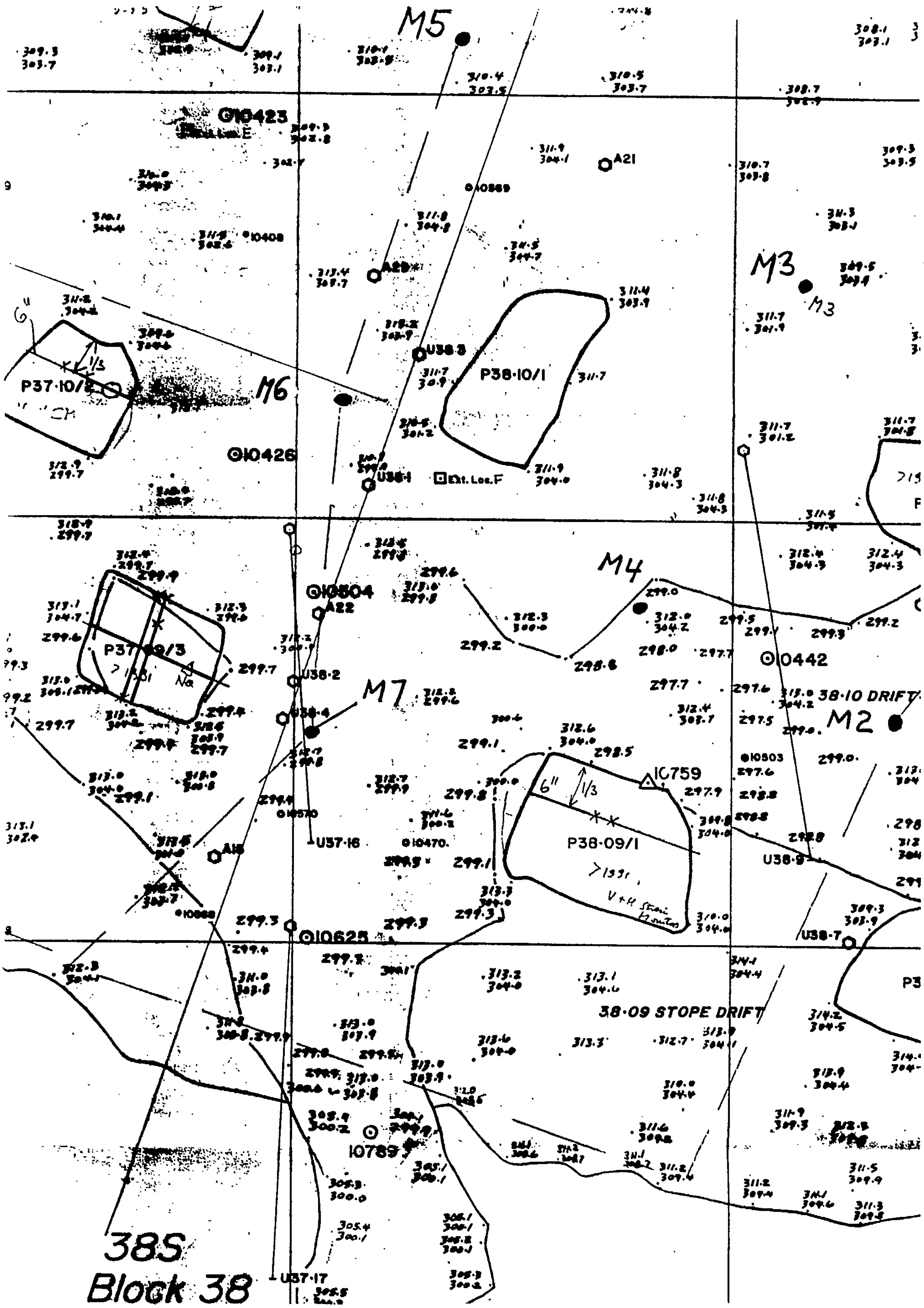

Fig. 2 Location of M2 to M6 drill holes.

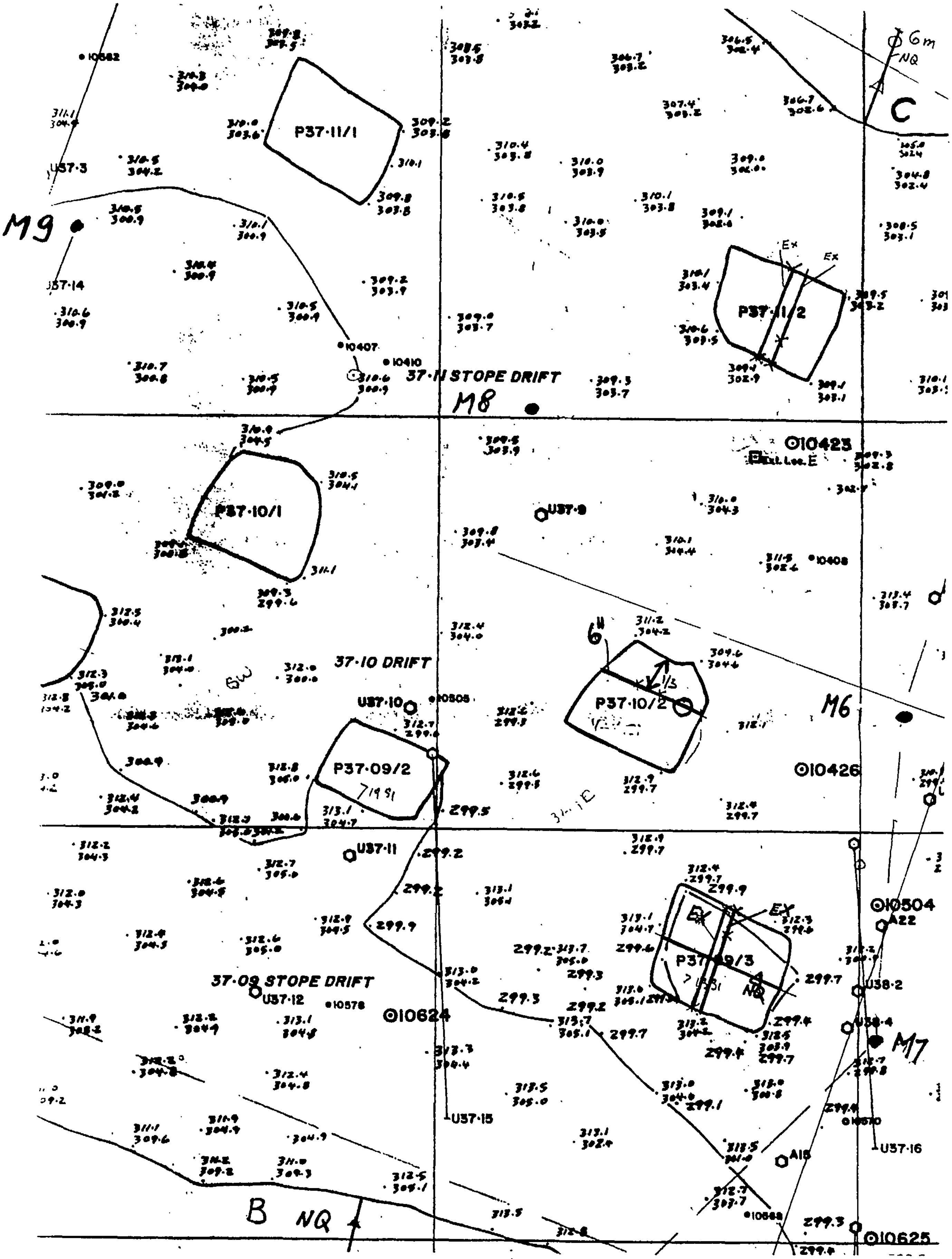

Fig. 3 Location of sites B, C.

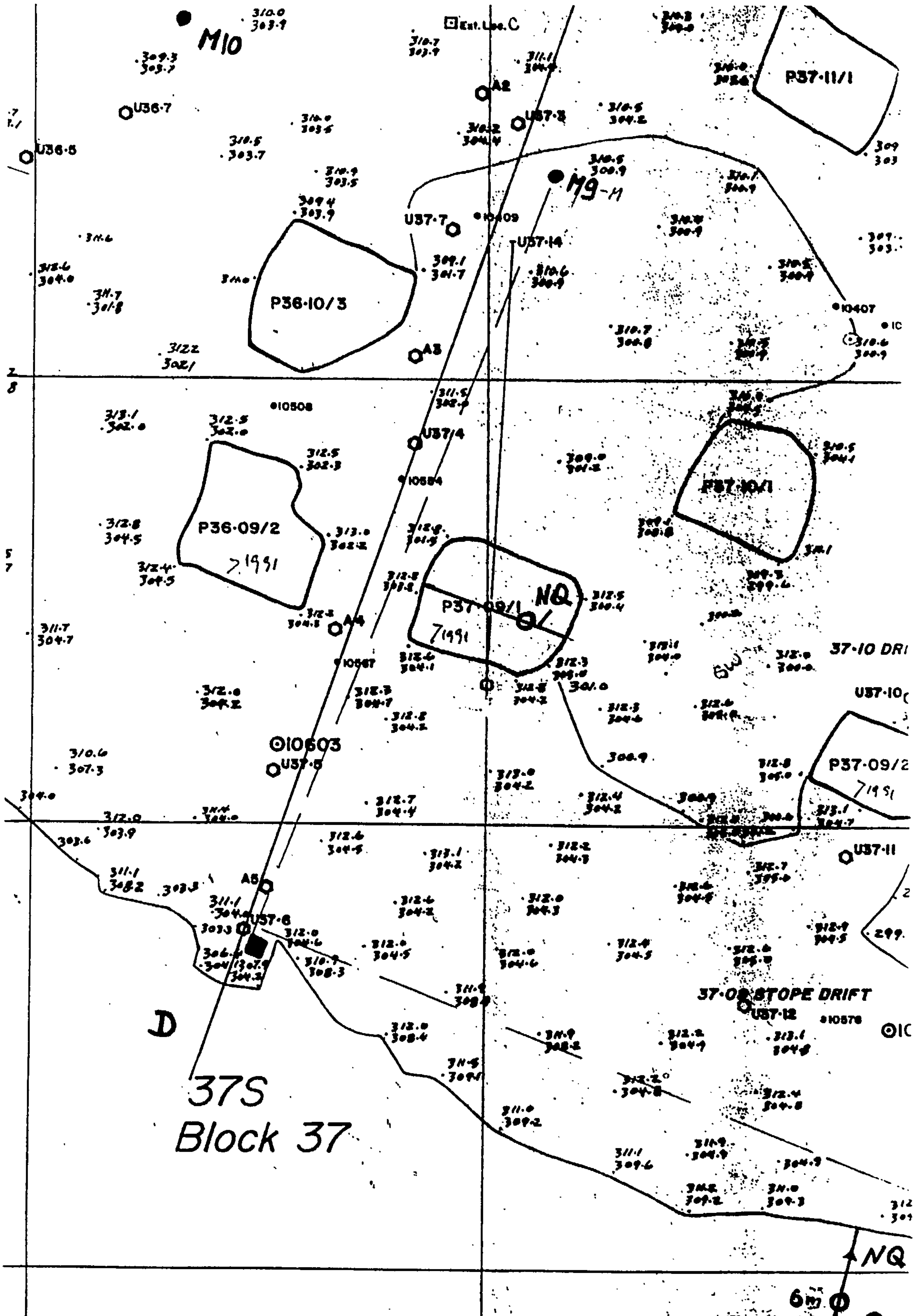

Fig. 4 Location of site D and M9 M10 drill holes

BLACK

19350 COMPRESSED

RED (COMMON)

RED

000 COMPRESSED

GREEN

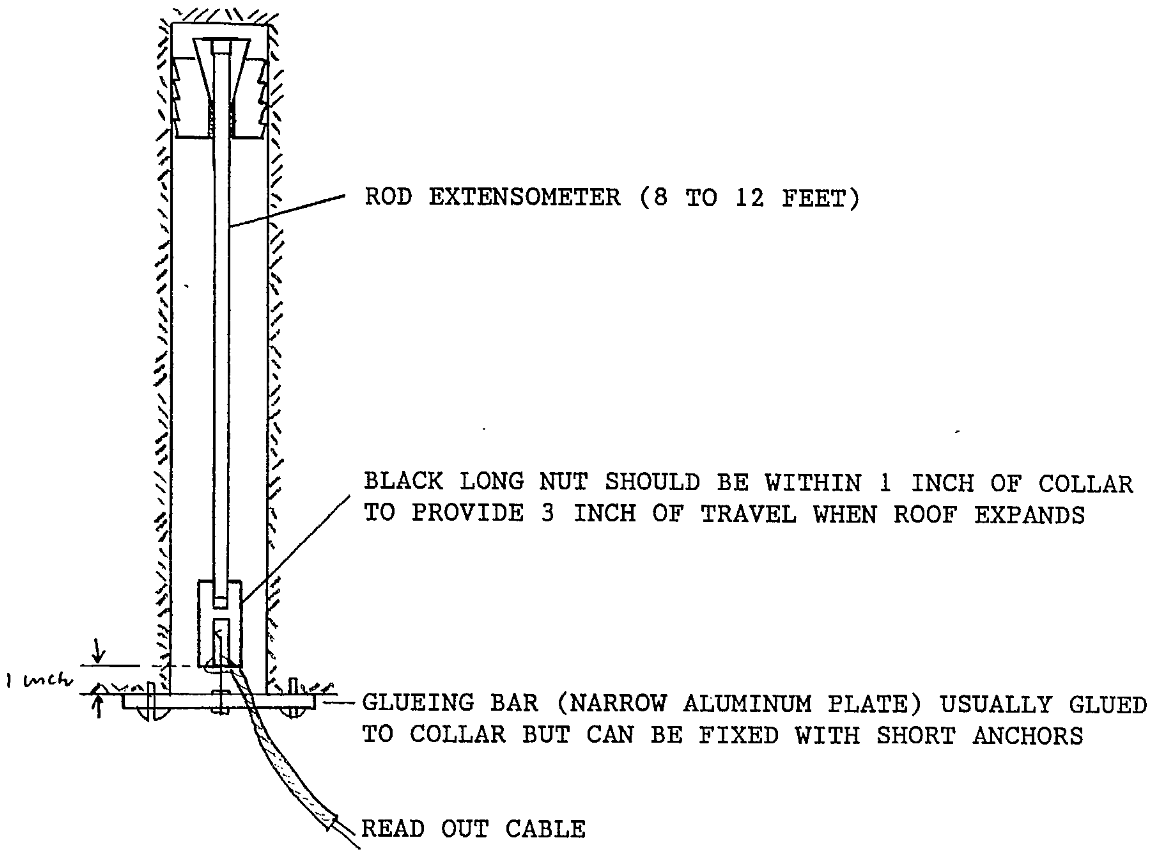

Fig. 5 Installation of ground movement monitor.