MONITORING LEVELS OF DEFORMATION WITHIN TARKWA COMMUNITY: A MULTI-GPS RECEIVER NETWORK SYSTEM APPROACH

Presented

by

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BACKGROUND INFORMATION

- Developments in the accuracies achievable by modern Global Positioning System (GPS) have made it reliable and effective in monitoring deformation patterns.
- The earth crust and engineering structures are subjected to deformation.
- For large scale monitoring of the effect of deformation, GPS technology should be adopted due to its advantages over the conventional surveys.

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STUDY AREA

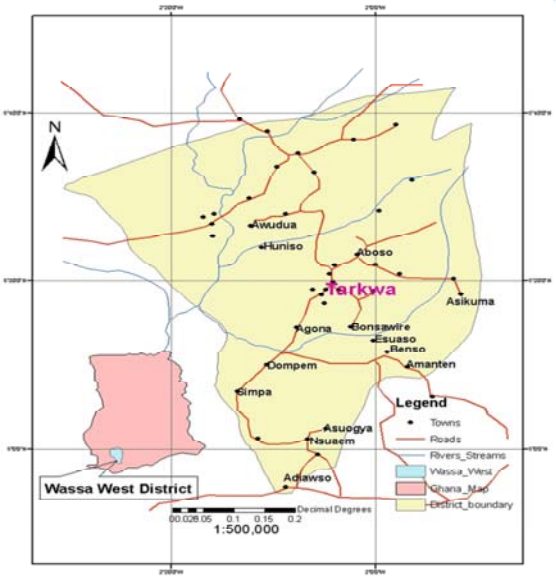

Figure 1 Map of Wassa West District showing location of Tarkwa

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CAUSES OF DEFORMATION

- Deformation refers to the changes a body (natural or artificial objects) undergoes in its shape, dimension and position. Such displacements are significant when they are sufficient to cause damage to buildings, structures or infrastructure.

- Natural factors - tidal phenomena, tectonic phenomena, earth quake, ground water level changes, compressible and collapsible soils, swelling and shrinkage of clay soils, landslides.

- Artificial factors (human activities) - mining, quarrying and engineering excavation.

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APPLICATION OF GPS IN DEFORMATION MONITORING

- Global Positioning System technique is applied in mining pit walls monitoring, land subsidence and landslides monitoring.
- Monitoring of long span bridges, overpass, dams, drilling platforms, high rise buildings.

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OTHER MONITORING TECHNIQUES

- Photogrammetry
- Electronic Tiltmeter/Inclinometer
- Optical Precise Levelling
- Interferometric Synthetic Aperture Radar (InSAR)

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STATEMENT OF PROBLEM

- Mining is a major activity in and around Tarkwa. The mining operations result in fragmentation of rock, ground displacement and vibration due to blasting.
- Inhabitants of Tarkwa are concerned with the safety of their structures whenever blasting occurs.
- There is the need for levels of deformation to be measured using GPS, since mining has been going on in the area over the past century.

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STATEMENT OF PROBLEM

Figure 2.1 Small Scale underground mine in Tarkwa

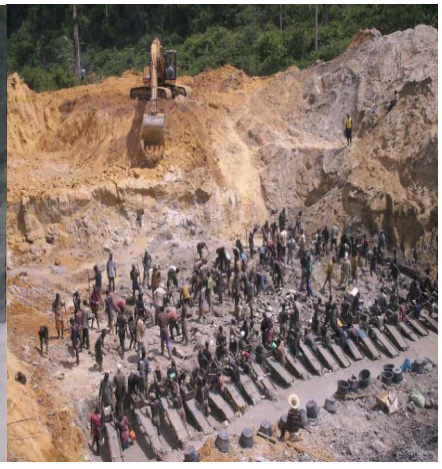

Figure 2.2 Small Scale surface mining

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STATEMENT OF PROBLEM

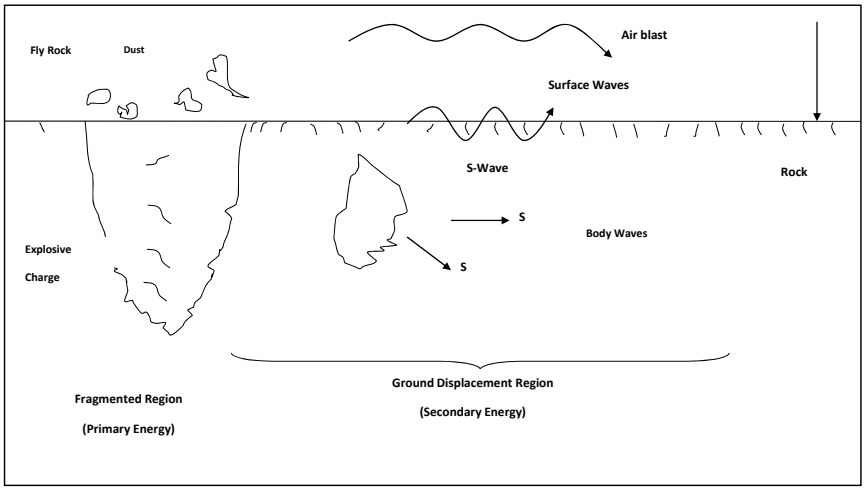

Figure 3.Schematic Representations of the Environmental Effects of Blast (Amegbey, 2006)

RESEARCH OBJECTIVE

- To monitor deformation of the earth crust within Tarkwa using GPS technology.

JUSTIFICATION OF OBJECTIVE

- GPS technique makes deformation monitoring very effective, accurate, efficient, less labour intensive, does not require inter-visibility, easy to process data and economical unlike conventional surveys.
- The continuous blasting operation within the area may have influence on the structures hence the need for levels of deformation to be determined.

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DATA COLLECTION AND PROCESSING

- The data collection span from the periods August, 2007 to January, 2008.
- Precautions were taken to reduce errors to acceptable levels.
- Data collection was carried out using the static differential GPS technique by leap-frogging method.
- Multiple receivers were deployed on the stations during the survey.
- The reference stations DMP RF 1 and 2 were occupied for a longer period of twelve (12) hours, in order to achieve higher accuracy in the estimation of the longer baseline length to the reference station.

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DATA COLLECTION AND PROCESSING (Cont'd)

- The GPS data was post-processed using sokkia Spectrum Survey Version 3.3 software.
- After blunders had been excluded using a minimally constrained adjustment, constrained network adjustment was performed.
- Chi Square Test on the Variance Factor.
- The effects of tides on earth movement was considered. A Fortran driver program written and compiled for use under MS-DOS was used to compute tidal corrections for gravity.

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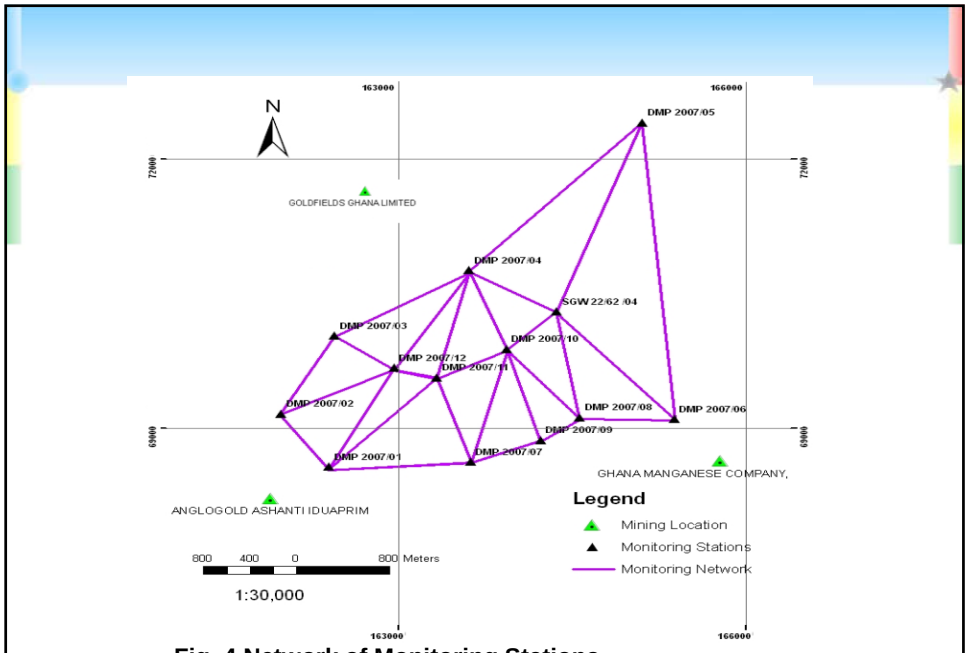

Fig. 4 Network of Monitoring Stations

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DATA VALIDATION

- Data validation was carried out to confirm this data using GPS surveys of some selected controls.

Table 1 Comparison of GPS coordinate and Established Coordinate by Precise Traversing method

STATION	ESTABLISHED COORDINATES				GPS COORDINATES				DIFFERENCES			
	E (m)	N (m)	Z (m)	D (m)	E (m)	N (m)	Z (m)	D (m)	E (m)	N (m)	Z (m)	D (m)
TSM 89/8	163401.020	69582.390	75.030		163401.022	69583.370	74.993		0.002	0.020	0.037	
TSM89/1A	163344.300	69582.660	75.940	56.720	163344.312	69582.866	75.717	56.712	0.012	0.206	0.223	0.008
TSM CT1	163426.900	69760.380	81.810	195.977	163426.899	69760.377	81.776	195.782	0.001	0.003	0.034	0.195
TSM 89/8				179.861				178.888				0.973

DATA VALIDATION Cont'd

Table 2 Comparison of GPS coordinates for different epochs of observations

STATION	GPS COORDINATES PHASE I				GPS COORDINATES PHASE II				DIFFERENCES			
	E (m)	N (m)	Z (m)	D (m)	E (m)	N (m)	Z (m)	D (m)	E (m)	N (m)	Z (m)	D (m)
TSM 89/8	163401.022	69583.370	74.993		163401.022	69583.370	74.993		0.000	0.000	0.000	
TSM89/1A	163344.312	69582.866	75.717	56.712	163344.312	69582.866	75.717	56.712	0.000	0.000	0.000	0.000
TSM CT1	163426.899	69760.377	81.776	195.782	163426.899	69760.377	81.776	195.782	0.000	0.000	0.000	0.000
TSM 89/8				178.888				178.888				0.000

- Survey pillar SGW 4 22/62 was included in the monitoring.
- Data was check for floating points

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DATA ANALYSIS

- Computations of the Horizontal movements (HM) and Vertical movements (VM).
- Computation of displacement/deformation levels (D).

Table 3 Average Movement of Stations in the Various Directions

STATIONS	VM (mm)	HM (mm)	D (mm)
DMP 01/07	-5	12	14
DMP 02/07	-10	4	11
DMP 03/07	-3	12	13
DMP 04/07	-8	11	14
DMP 05/07	-11	7	13
DMP 06/07	-3	5	5
DMP 07/07	-2	3	2
DMP 08/07	-2	4	4
DMP 09/07	-1	6	6
DMP 10/07	-7	8	12
DMP 11/07	-2	6	7
DMP 12/07	-7	10	12
SGW 04/22/62	-8	5	9

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DATA ANALYSIS (Cont'd)

- Analysis of Variance (ANOVA) on deformation levels.
  Hypothesis testing

$$H_0 := \mu_1 = \mu_2 = \mu_3 = \ldots$$

H_1: At least one mean is different

Significance level (SL) = 5%

Table 4 Analysis of Variance of Displacement of various Points

ANOVA	df	SS	MS	F	Significance F
Between Points	12	1896.887	158.074	10.654	1.836
Within Points	117	1735.975	14.837		
Total	129	3632.863			

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RESULTS AND DISCUSSIONS

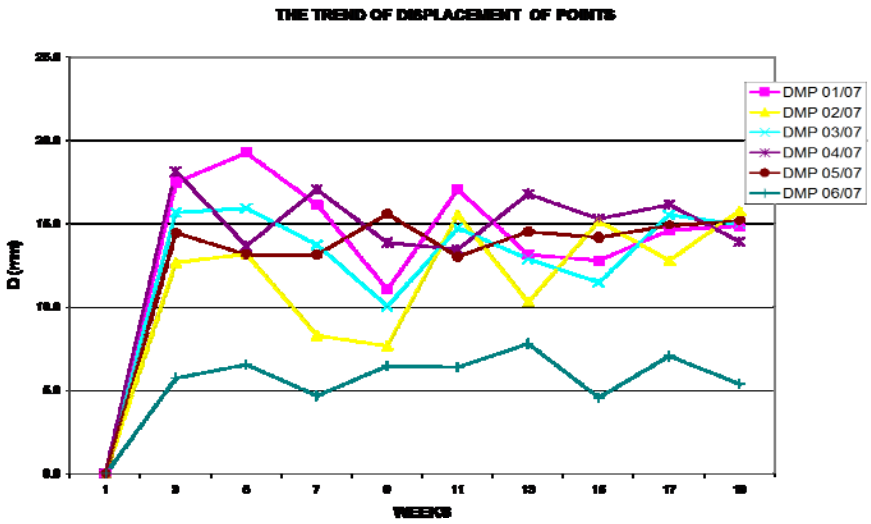

Figure 5a Graphs of Displacements

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RESULTS AND DISCUSSIONS (Cont'd)

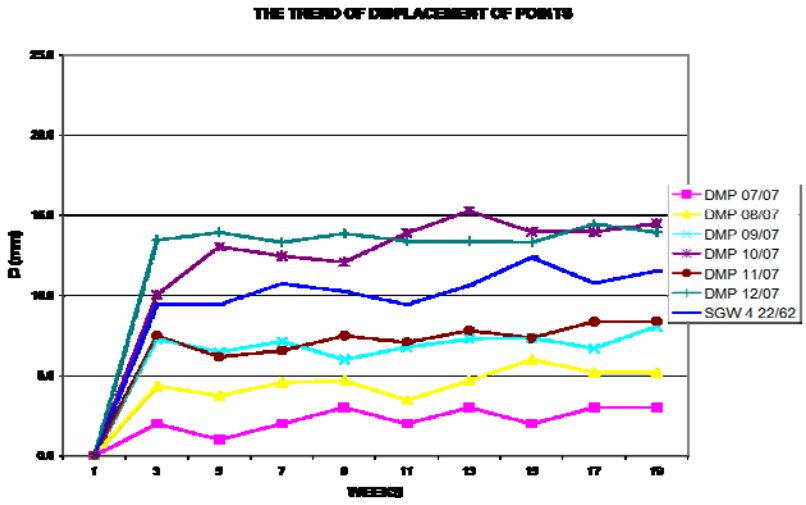

Figure 5b Graphs of Displacements

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RESULTS AND DISCUSSIONS (Cont'd)

- Trends for deformation levels found for all the points were within the range of 0.00 to 19.00 mm
- The high levels of deformation occurred in the points DMP 1,2,3,4,5, 10 and 12 which were within 200 to 500 m from the epicenter.
- Other points such as DMP 6, 7, 8, 9 and SGW 4 22/62 had relatively small deformations. These points were within 1000 to 2000 m from the epicenter.
- Also policies should be drawn up for improved ways of waste management
- Members of the Communities should be given intensive education on the need to disposed waste at selected sites.

CONCLUSIONS

- The results indicated that the GPS modern technique is very reliable for earth surface Crustal monitoring survey. Thus useful to be utilised for a wide range of scientific applications.
- Since the deformation values fluctuate from 0.00 to 19 mm it implies that there is some significant movement.
- Despite the limited area covered by this study, the investigation has been successful in determining the deformation patterns of the study area.


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