# 4.3.7. LOCAL INSTRUMENTAL INVESTIGATIONS OF GEODYNAMIC PROCESSES IN BULGARIA

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## 4.3.7.1. Introduction

**Initial measurements and investigations were made in the remote past – there were documented cases in the first half of the last century. This referred mainly to landslides and terrain deformations around mine workings. Valuable quantitative information was obtained about the changes of the Earth's surface during the earthquakes in Upper Thrace in 1928 from precise levelling before and after their occurrence (DIPOZE, 1931, Yankov, 1945). The instrumental control found wider application and development in the second half of the 20$^{th}$ century, new and more and more modern methods being involved in it. The idea about the establishment of a National system for monitoring of geodynamic processes is still pressing, especially in the context of the continuing disasters and catastrophic events in the recent years. The solution of this problem requires much time and resources and hence it should be carried out in stages, the highest priority belonging to: the most hazardous processes, the most strongly affected territories with high degree of urbanization, the threatened monuments of the cultural-historic heritage and the investigations of long duration needing initial base records.**

## 4.3.7.2. Geodynamic processes of contemporary activity

**Various types of geodynamic processes take place on the territory of Bulgaria, which is situated in an active tectonic zone, these processes being characteristic for the other Balkan countries too. Most of these processes are included in the structure of the geological hazards (Broutchev (Ed.) et al., 1994). A part of them possess the characteristics of disasters and catastrophes: earthquakes, landslides, rock-falls, avalanches, torrential phenomena, storms, abrasion and a group of phenomena in underground mine workings (sudden water inrush, caving, poisonous and explosion-hazardous gases). Except for the material losses, they threaten the life and health of the population. Another part of the processes with although slow but permanent effect on large areas exert great damages to the material funds and the environment: erosion, karst, collapse in loess terrains, phenomena related with shallow groundwater – bogginess, salinity, aggressiveness, etc. The weathering and slope processes cause heavy and irreversible damages to the cultural and historic heritage.**

**These processes take place on the background of slow tectonic movements – rising and sinking of the Earth's crust blocks, movements along faults, including in horizontal direction. They predetermine and control the destructive processes on the Earth's surface to a significant extent.**

**The concern of society in the complex geodynamic circumstances in the country, the high degree of the hazards and risks due to certain phenomena and their consequences is reasonable. The instrumental control of the geodynamic processes is an important element in the system of measures for reducing the risks.**

## 4.3.7.3. Instrumental monitoring and results

**The instrumental monitoring in Bulgaria involves application of various methods. The accuracy of the applied methods of monitoring depends on the type of the monitored phenomena, their size, rate of movement, and the purpose of observation. Subjects of monitoring are the landslides, rock-topples, fault movements, and river and sea erosion. Nominally, the monitoring is connected with practical use, for the safety of human lives and historical heritage. The methods vary from geodetic ones to highly precise extensometric ones.**

**The most important and widely applied methods are the geodetic measurements. They are carried out for many places. They are used mainly for landslides, and rarely for terrain subsidence (near Provadia) and local tectonic movements.**

**Nowadays the monitored landslides are located in different parts of the country. The purpose of their observation is almost practical - for safety of urban areas, roads or railways. The first known case in Bulgaria of applying monitoring tools is described for the Pernik open-pit coalmine in 1956 (Vulev, 1959). Other landslides in Bulgaria had been monitored during different periods (Table 4.3.7.1). The monitoring of the largest and deeply-seated landslides affecting the densely urbanized shoreline area along the North Black Sea coast (near Balchik, Varna and Sarafovo) was started during the 1960s. Later, the monitoring covered other landslides occurring along the Danube River bank and in the countryside. The first used monitoring approaches were connected with geodesy and inclinometry. The system of geodetic benchmark set was developed and supported at landslides along the Black Sea coastline (also at Fichoza, Shkorpilovtzi, Ravda, Sarafovo and Chernomoretz) and the Danube River bank (Slivata, Oryahovo, Lom, Gorni Cibar and Svishtov). Such measurements were performed also for many landslides in the countryside, for example, in Veliko Turnovo, Gabrovo, and other towns in Bulgaria (Georgiev, 1973, Milev et al., 1992a,b, Todorov et al., 1992). Geodetic benchmarks were arranged as well at some landslides affecting the road network and urban areas in Bulgaria. Recently the GPS measurements are coming in the practice. Such measurements were applied at the General Geshevo Landslide (East Rhodopes) and for the study of tectonic movements in SW Bulgaria.**

**Sea erosional processes along the coasts of the Black Sea and river erosional processes along the Danube River were monitored using erosional benchmarks (Shuysky, Simeonova, 1982, Simeonova, 1988). At some places significant values were established for the coast line inside the country reaching 0.5-1.0 m (Table 4.3.7.1.).**

**Inclinometry was used for a restricted number of landslides in Bulgaria (Fig. 4.3.7.1.). This method was applied for the large landslide at Svishtov; the landslides in the Pernik open-pit coal mine, Dupnitsa, and others.**

**A method with application of multi-wire cable in borehole has been used for determining the depth of the slip surface of the Krupnik landslide in 1987-1989 (Dobrev, 1997). The slip surface was detected at a depth of 14.5 m. Some elementary tools for observation of landslide movements were applied additionally at the landslides of Krupnik, Dupnitsa and Zemlyane (in the Sofia City).**

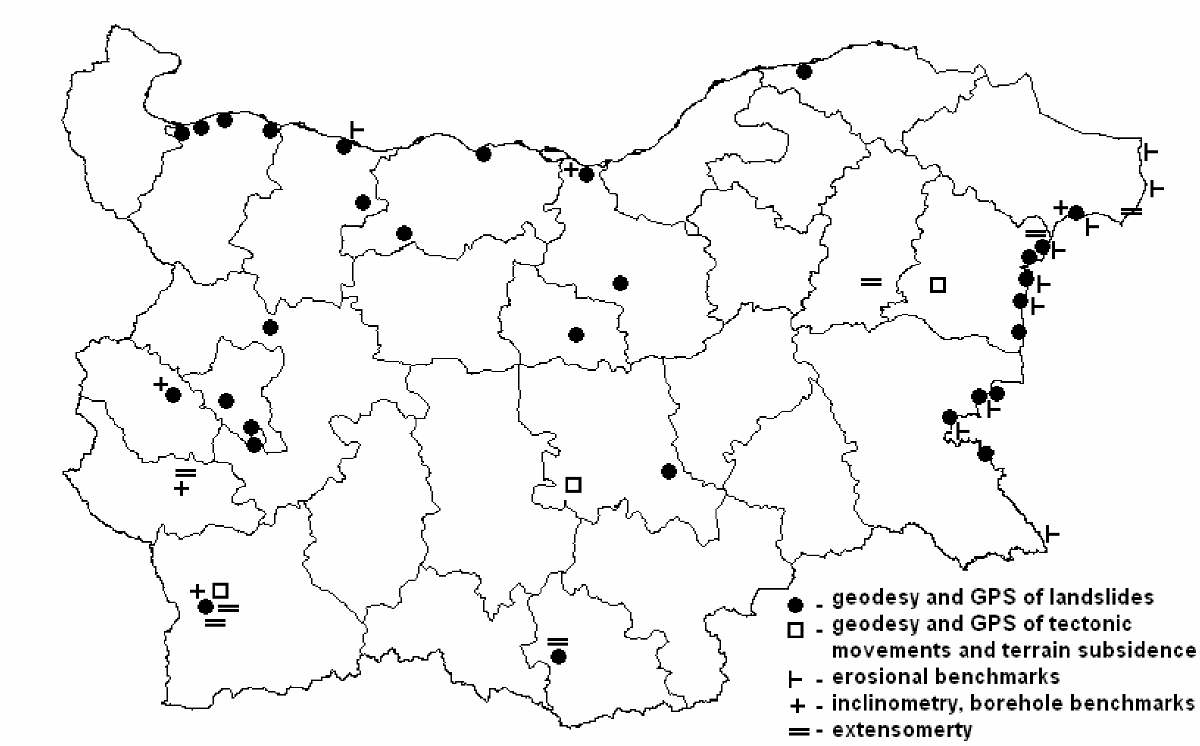


**Fig. 4.3.7.1. Scheme of the different types of local measurements of geodynamic processes in Bulgaria**

**Table 4.3.7.1. Example of monitored geohazard processes in Bulgaria and obtained results**

| Landslide | Monitoring method | Period of observation | Obtained results |
|---|---|---|---|
| Landslides at Varna's coastline | Geodesy | 1960s till now | 40 - 50 mm/year |
| Zlatni Pyasatsi area, Varna district, Black Sea coastline | Extensometry | 1981 - 2000 | 0.5 mm/year |
| Balchik landslide, Black Sea coastline | Geodesy, inclinometry sea-erosion benchmarks | 1969 - 1993 1987 - 1996 1977 - 1988 | 35 - 60 mm/year, 10 – 50 mm/year up to 1 m/year |
| Taukliman landslide, Dobrich district, Black Sea coastline | Extensometry | 1972 - 1993 | 1.2 mm/year |
| North Black Sea coast, Sivriburun Cape - Shabla, sea erosion | Benchmarks | 1972 - 1982 | 1 m/year |
| Gorni Cibar Landslide | Geodesy, dilatometry | Apr.1980 - Dec.1981 Apr.1980 - Dec.1981 | 7.6 – 73.0 mm/year, 153 - 492 mm/year |
| Oryahovo, river erosion | Benchmarks | 1978 - 1979 | 1.0 – 1.2 m/year |
| Danube River Lowlands, shallow ground water table fluctuation | Boreholes | 1980 - 1990 | 4 - 5 m/year |

| | | | |
|---|---|---|---|
| **Madara rockwall deformations** | **Extensometry** | **1990 - 2002** | **0.9-1.0 mm/year** |
| **Provadia salt mine terrain subsidence** | **Geodesy** | **2002 - 2003** | **up to 32 mm total subsidence** |
| **Ezerishte landslide, Svoge area** | **Geodesy** | **13.11.2002 - 19.11.2003** | **95.9 – 111.0 mm/year** |
| **”Botanical garden” landslide, Sofia** | **Geodesy** | **1986 - 2002** | **15 mm/year** |
| **Landslide near Dupnitsa town** | **Geodesy, inclinometry, extensometry** | **2002 - 2003 2002 - 2003 2002 - 2003** | **2.7 – 8.1 mm/year<br>0 – 0.043 rad/year<br>4 - 18 mm/year** |
| **Krupnik landslide, Blagoevgrad district** | **Geodesy, borehole benchmarks** | **1987 - 1988 1987 - 1989** | **no data slip surface at 14.5 m** |
| **Krupnik fault** | **Extensometry** | **1983 -** | **2.7 mm/year strike slip** |
| **Struma fault** | **Extensometry** | **1982 -** | **< 0.5 mm/year strike slip** |
| **Maritza Iztok Troyanovo-2 open-pit coal mine** | **Geodesy** | **1966 - 1977** | **70 - 740 mm/year** |
| **General Geshevo landslide, Kurdjali district** | **Extensometry, GPS** | **07.2003 - 10.2005 2001 - 2005** | **1 - 6 mm/year up to 50 m maximum displacement** |

**The 3D monitoring is based on the use of mechanical-optical gauge TM-71 with high precision, made in the Czech Republic (Kostak, 1991). It is applicable for detection of very slow movements, especially for landslides (Taukliman, Zlatni Pyasatsi, General Geshevo), rock deformations (Madara Horseman) and active faults (Krupnik and Struma faults). The selected active faults were monitored for establishing the real rates of their movements. The device was applied in the Krupnik-Kresna epicentral area (Dobrev and Kostak 2000). However, the GPS and extensometric measurements (with TM-71) require a long period of observation in order to avoid the permissible error especially for the slow rates of movements.**

**The results from these instrumental studies helped for the solution of many practical and scientific tasks. The coordination of the instrumental studies between different institutions in Bulgaria and the collecting of data into uniform information system are necessary.**

### 4.3.7.4. On the future research

**The geodynamic processes as a substantial part of the environment and especially those bringing disasters and catastrophes have to be subjected to systematic control in order to ensure effective counteraction measures. The preventive measures are more economical and their selection and substantiation are motivated to a great extent by the results of the instrumental investigations. The necessity of their development is indisputable and it may be realized in the following directions:**

- **Territorial extension of monitoring on processes that had been controlled so far;**
- **Including new processes in the instrumental investigations;**
- **Modernization and improvement of the measuring systems – automation, signalization, introduction of new methods;**
- **Composing information systems for acquisition, analysis and generalization of information and development of assessments, predictions and recommendations for state decision making;**

**- Exchange of information from the measuring systems of the neighbouring Balkan countries in the parts of mutual interest, searching for and juxtaposing regularities, coordination of the monitoring of geodynamic processes.**

## 4.3.7.5. Conclusions

**The territory of Bulgaria is loaded by a broad spectrum of geodynamic processes included in the structure of the geological hazards, some of them having the nature of disasters and catastrophes. They represent a threat for the life and health of the population, for the safety of material funds and the quality of the environment. This is the reason for undertaking the necessary measures for restricting and reducing the risks and where possible – for preventing the negative consequences. The scientific investigations, including the instrumental control of the hazardous processes, occupy an important share in the system of various types of activities. This control should be subjected to development, broader application and improvement, which will contribute to attaining sustainable development of society in calm and safe natural environment.**

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