

**ABOUT CONDITION AND MODERNIZATION  
OF SURVEYING AND GEODETIC MONITORING SYSTEM  
OF OIL AND GAS FIELDS AREAS FOR MAINTENANCE  
OF INDUSTRIAL SAFETY OF THEIR DEVELOPMENT  
AND CONTROL FOR THE DEPOSITS**

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There are two opposite points of view on a question of presence of Earth surface deformations caused by oil and gas fields development. The first point of view is that oil and gas fields development causes extensive area subsidence. The second point of view is that oil and gas taken out from pores of a reservoir is replaced by the incompressible fluid – water – if the hydrocarbons are water-driven – and consequently no man-caused subsidence is present.

At the same time Earth surface displacements monitoring in oil and gas fields areas is regulated by "The Instruction on Surveying Operations. RD-07-603-03" by Gosgortekhnadzor (Russian State Engineering Supervision Instance). This monitoring must include creation of the fixed reference points system both in limits of hydrocarbon field contour and outside of it (i.e. in the area of possible man-caused deformation and outside of this area). Traditional methods of regular measurements (mostly 2<sup>nd</sup> class leveling) should be applied on this system of points.

Such approach, according to the experience of LLC "Gazprom dobytcha Urengoi" for example, requires creation of system of measurements with extent of leveling courses of about 1400 km. It leads to great financial expenses even at the stage of fastening of the reference points because it requires drilling them in to a certain depth due to conditions of the Far North (where most of JSC "Gazprom" currently developing oil and gas fields are situated). And such reference points should be placed each 300-500 meters (in zones of tectonic dislocations – each 100 meters) so it is impossible to use production wells' heads for fastening them because production wells are highly non-uniformly spaced – they are concentrated mostly in the central axis of the field, while reference points should be uniformly spaced with required density on the area of an oil and gas field. High-precision geodetic measurements are extremely expensive too. Besides they require significant amount of time and, as a result, full cycle of measurements is finished on each second, or even on each third field season (according to the experience of LLC "Gazprom dobytcha Urengoi").

Lately JSC "Gazprom" began applying new techniques for displacements and deformations monitoring of Earth surface and rocks, overlapping gas bearing formations, based on GPS-measurements on the very limited quantity of control points – GPS-stations. These stations, situated inside oil and gas fields contours, are integrated into International Geodynamic System of GPS-stations (IGS). They allow to measure latitude, longitude and height in real time mode with accuracy of about 5 mm. Therefore this technology provides opportunity to monitor Earth surface displacements in several points inside field's contour.

For the monitoring of Earth surface displacements on the whole area of a field (or group of fields) authors suggest to apply an innovative techniques of satellite-based differential radar interferometry. This techniques allows to map displacements of the reflective surface by means of interferometric processing of time series of radar images of the same area. Specific character of interferometric processing of radar images series requires removal of phase noise from resulting interferogramme and refinement of radar satellite orbit. These problems can be solved by use of data, acquired from above-mentioned GPS-stations, equipped by corner reflectors of the radio-signal. Moreover, limited quantity of corner reflectors should be set

along the field's area – to provide uniformly spaced net of ground control points for satellite radar imaging. On these reflectors differential GPS-measurements should be regularly executed. Temporal interval between radar images in time series and type of radar are chosen separately and individually for each field (taking into account natural tectonic activity in the region, geodynamic situation, intensity of hydrocarbons production etc).

The output of differential interferometric processing chain – displacement map in isolines – is characterized by accuracy of about several millimeters in height direction (in case of multi-pass method of persistent scatterers). This displacement map is calibrated by ground control points (GPS-stations with corner reflectors and separate corner reflectors) and it can be renewed with the required time interval. Then the displacement map is comparatively analyzed with geological, geophysical and field-geological information to separate natural and man-caused components of displacements. Extra-control of suggested method can be done by means of traditional instrumental high-precision measurements (like leveling) which are executed with much less frequency.

Based on all the above-mentioned, authors suggest to modernize the system of surveying and geodetic monitoring of oil and gas fields areas for maintenance of industrial safety of their development and for monitoring of the deposits by inclusion in this system the suggested technology of satellite radar differential interferometric area monitoring of Earth surface displacements with point calibration based on high precision differential GPS-measurements on uniformly spaced corner reflectors.