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Analysis of Spatial Distribution and Mechanism of Formation of Fissures due to Land Subsidence in Neyshabur plain

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Abstract

In many plains of Iran, including those in Neyshabur plain in Northeast of Iran, the dangerous phenomenon of subsidence has occurred. This plain is the second most important in Khorasan Razavi Province, after Mashhad plain, in terms of groundwater harvesting and also fertility. The main source of water supply in this plain is groundwater resources. Due to over-exploitation of groundwater resources, land subsidence has occurred and tension fissures and splits have appeared on the surface in different parts of this plain. The main purpose of this research is to analyze the distribution and mechanism of Fissures formation caused by land subsidence. Using Sentinel 1 satellite sensor data, the land subsidence range in this plain was investigated and using Quick Board and Sentinel 2 sensor data which have a high spatial resolution, the Fissures in subsidence zone were determined. Then, during field observations, the existence and position of these Fissures were verified and, using GPS, full coordinates of the Fissures including 25.5 km of continuous and discontinuous Fissure and 181 Fissures were mapped and a map from the plain's Fissures was drawn. In addition, the possible and covered Fissures in different areas of the plain were studied and identified in the maps. Geo-electric data from the plain and the condition of bedrocks were analyzed based on conceptual models of Fissure formation. Based on the investigations and taking into account the geometric shape and condition of the plain and its subsurface, it can be said that: the mechanism of the mechanical-based model, the mechanism of aquifer materials' heterogeneity as well as tension stretch mechanism, are the most important mechanisms in the Fissure formation in Neyshabur plain.

Keywords: *Land Subsidence, Fissure formation mechanism, Fissure distribution, Neyshabur* Plain

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Extended Abstract:

1. Introduction

Nowadays, one of the serious problems in plains around the world is the land subsidence phenomenon and appearance of tension Fissures on the surface, which results from exploiting water resources. This phenomenon expands slowly and gradually. Land subsidence can be considered a morphological phenomenon, and a wide range of morphological complications due to this phenomenon occurs in the plains. The subsidence phenomenon have many morphological effects on the land's surface, such as morphological disturbances, damage to human installations (buildings, highways, streets and passages (Chen et al. 2010)), disturbance in the hydrological flow (Barends et al. 1995), saline and freshwater interference and destruction of subterranean installations (Sharifikia, 2012). Studies carried out on the morphological effects of land subsidence in the world and Iran are scarce and just addressed briefly in related studies. Subsidence is usually hundreds of meters long. In 2002 a 1000 meter long Fissure appeared in west of Miaozhuang, China (Xu, J et al. 2019). Land subsidence which is a major morphological effect caused by excessive exploitation of groundwater in plains has been studied by several researchers. Most of the mechanisms proposed to create Fissures due to reduction in the groundwater level were based on field observations and conceptual models, happen after the Fissure occurrence in land surface (Adiyaman, 2012). Badhu and Adiyaman (2009) categorized the land Fissures into five groups: Beam Model or bending expansion on top of stack mechanism, tensile stress, tensile stretch model, horizontal penetration model in the aquifer and mechanical-based model. In this classification, the relationship between the Fissures and possible mechanism are coincide with stress and strain caused by the reduction of groundwater level.

This research was carried out in the northeast of Iran, in Neyshabur plain, which is 90 km long and 36 km wide. Spatial distribution of the Fissures and mechanisms of their formation were analyzed according to the existing information.

1. Materials and Methods

The methodology used in this study was empirical, surveyed, analytical and documentary. First, by collecting and reviewing related articles and reports, as well as geological maps, topography and satellite imagery, geophysical reports and groundwater information, the status, and condition of the research area was evaluated. Then, by performing desert observations and inspections across the plain, all the complications and specifications of Fissures were taken using GPS-based Garmin Model 62S, and the Fissure maps were drawn on the scale of 1/20000 and 1/25000 in ten separate parts of plains where Fissures were observed. Subsequently, available information from 464 geoelectrical soundages which were taken in the form of 31 profiles across the plain were used. In some cases, these profiles crossed the Fissures. These geophysical data were used to determine the condition and status of the bedrock and sediments in that area, and the probable mechanism of the Fissures was analyzed.

2. Test Results

At the land surface and in the area of Neyshabur plain, the subsidence landforms are very diverse, from Fissures and depression to circular ditches and gullies with different shapes and phenomena which distinguishing them from other natural drains is difficult. The four landforms introduced by

Shipman and Diaz (2008) in the protocol prepared for drawing maps of Fissures in Arizona Geological Survey, were also identified in Neyshabur plain. Land subsidence studies By radar data of Sentinel 1 and Quick Board and Sentinel 2, which have high spatial resolution, in Neshabur plain, show some Fissures at the edge of the plain. These fissures verified in-field inspections using GPS and maps of Fissures were drawn. These Fissures included 25.5 km of continuous and discontinuous Fissure, and 181 possible and covered Fissures in the plain areas were also included in the maps.

Rose diagram related to the Fissures' direction through Neyshabur plain, shows the dispersion of the Fissures process which is affected by land subsidence in Neishabur plain and its asymmetric shape, which varies by the thickness of alluvium and sedimentary conditions. The results show that the mechanism of Fissures formation is probably different in each area. Also the rose diagrams of Fissure trends help to prediction of new fissures in the future which can be useful in studying the future agricultural and developmental activities in these areas. The analysis of geoelectric studies in Neyshabur plain help to determining faults and fractures, thickness of alluvial deposits, debris and the weathered part of the stone floor. We can use the existing information, in addition to field studies and technical analysis to investigate bedrock in the Fissure areas and to adapt these data to conceptual models of the mechanism of creating Fissures in land subsidence in each area. According to the studies, the mechanical-based model and the mechanism of aquifer materials' heterogeneity and differential displacements in which the Fissures are formed in the boundary of subsurface and stable regions, most models are in the mechanism of Fissure formation in Neishabur plain.

1. Conclusion

- Studies show that the Fissures created by the reduction in water level, are the most common morphological forms of the plains. These Fissures have been formed with different shapes and morphology in some parts of the plain.
- The results of geoelectric studies were used for subterranean studies. In geoelectric profiles, there is a good correspondence between the geoelectric transverse section and the Fissures' area. Fissures are seen on the site of floor rock changes, or change and displacement of fine-grained layers (Aquitard).
- By drawing cross-sectional plans in the most important areas where Fissures passed, and considering the information regarding bedrock and the thickness of alluvium, mechanism of Fissure formation with mechanical-based model, the horizontal penetration model in the aquifer heterogeneous deposits and tension stretch model are more consistent in Touzandeh Jan, Bazoubandi, Karim Abad, Karizak Kenar Kal, and Boshroo.

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