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Use of twin GRACE satellite gravity data and geoid signals in the characterization of major underlying aquifer regimes and tectonic structure of the Middle Indus Basin, Pakistan

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Abstract Geoid signals provide important information about the subsurface density structure of the Earth and can be effectively utilized for the identification of mass anomalies at depth with respect to the characterization of buried features, i.e. aquifers, minerals, oil and gas reservoirs, and tectonic boundaries. Due to long wavelength characteristics, geoid signals can be more useful in studying regional and global anomalous structures. Longer wavelength geoids correspond to the lower mantle signals and shorter wavelengths depict the heterogeneities in the lithosphere. Moreover, underlying aquifers of various characteristics tend to exist due to the tectonic hierarchy, active fault plains, and the nature of terrains consisting of alluvial flood plains and potwar strata. This study encompasses the impact of geoid models, gravity, topographic and satellite data that was used in the detection of specific plate tectonic boundaries responsible for generating the earthquakes and vast plains along fault lines containing unconfined and confined groundwater aquifers of variable yielding capabilities. To circumvent the hypothesis, a precise gravimetric geoid model was determined for Pakistan and surrounding areas using the EGM2008 gravity model. In addition to this, twin GRACE satellite gravity data have been utilized in the detection of major tectonic boundaries and aquifer characterization. The monthly gravity solutions of GRACE satellite data have been compared for the year 2005 to establish the relationship of time variable gravity fields with tectonic, geological and water bearing structures. With the conclusive findings from the study, it has been observed that the horizontal gradient of the geoid, density variation in buried masses, aquifer geometry and characterization, and tectonic structure can be related to each other. A significant correlation can be seen between the lateral geoid gradient and the distribution of vast flood plains in the Middle Indus Basin. The density of the buried masses is attributed to the location of suitable aquifers in the areas of maximum geoidal slope.

Key words geoid; gravity; geoidal slope; EGM 2008; GRACE satellites; Indus Plain