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# Mapping of weathering, erosion and morphogenetic zones of Namak lake basin of Iran by Peltier's graphs

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**ABSTRACT**

*Peltier in his article published in 1950 by Association of American Geographers (AAG), seven models for the determination of chemical weathering, frost action, weathering regions, pluvial erosion, mass movement, wind action and morphogenetic regions based on mean annual temperature and mean annual Precipitation, is introduced. In order to we first selected synoptic weather stations with long-period data in the period 1956 to 2005 and then annual rain and temperature was calculated for each station. Using relationship between this parameters and elevation and a digital elevation model (DEM) with a resolution of 30 meters, average precipitation and temperature maps of the basin were obtained in Arc-Map. Seven graphs based on temperature and precipitation was coordinated in global map and import to Arc-map. Zones observed in basin include: maximum and moderate in wind action, very slight and slight mechanical in weathering, weak in chemical weathering, absent and weak in frost action, minimum and moderate in mass movement, maximum, minimum and moderate in pluvial erosion and arid, semiarid, savanna and boreal in morphogenetic regions.*

**Keywords:** Erosion, Morphogenetic zones, Namak lake basin, Peltire model, Weathering.

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## INTRODUCTION

Weathering is the gradual destruction of rock under surface conditions. Weathering may involve physical processes (mechanical weathering) or chemical activity (chemical weathering). Some workers also include the actions of living things (organic weathering), although these can also be classified as mechanical or chemical or a combination of both. Weathering can range from a change in color all the way to the complete breakdown of minerals into clay and other surface minerals. Weathering creates deposits of altered and loosened material, called residue, that are ready to undergo transportation and thus be eroded. Erosion means weathering plus transportation at the same time. Weathering is necessary for erosion, but a rock may weather without undergoing erosion. Peltier [5] geographical cycles under the glacial geomorphology in relation to climate studies and seven models of weathering and morphogenetic presented. Peltier's paper is a standard that is still used today to describe the weathering processes of the Earth. The focus of his paper was on the different types of weathering and erosion that are occurring due to the amounts of rainfall and temperature. These models are: chemical weathering, frost action, weathering regions, pluvial erosion, mass movement, wind action and morphogenetic regions [1]. Chemical weathering (also known as decomposition or decay) is the breakdown of rock (weathering) by chemical mechanisms, the most important ones being carbonation, hydration, hydrolysis, oxidation, and ion exchange in solution. Chemical weathering changes the composition of the rock material toward surface minerals, such as clays. It attacks minerals that are relatively unstable in surface conditions, such as the primary minerals of igneous rocks like basalt, granite or peridotite. Water is especially effective at introducing chemically active agents by way of fractures and causing rocks to crumble piecemeal or by loosening thin shells of material (in spheroid weathering). Chemical weathering may include shallow, low-temperature alteration. The weathering process caused by cycles of freezing and thawing of water in surface pores, cracks, and other openings. Alternate or repeated cycles of freezing and thawing of water contained in materials; the term is especially applied to disruptive effects of this action. Frost action can also be termed as the mechanical weathering graph since it captures the areas where lack of high temperatures lend to more mechanical weathering than chemical weathering. The graph defines where there are significant amounts of precipitation and the freezing point is breeched often. This allows for freeze and refreeze, thus breaking down rock formations by mechanical means, i.e. rubbing, grinding and grating actions. The frost action graph takes into account the areas where the mean annual temperature and precipitation are causing this effect, thus causing the most mechanical weathering. The increasing temperature and increasing precipitation until the temperature is too high to allow for sufficient freeze thaw cycles to cause the mechanical weathering to take place define the other gradual regions. The weathering regions graph is a combination of the chemical weathering and frost action graphs. These two graphs when combined create the Weathering Regions since each is at the opposite spectrum of the Temperature means. Pluvial erosion is the amount of erosion that is caused by higher precipitation amounts over a given area. The regions of the pluvial erosion graph are perhaps the most confusing, since the areas with the greatest amount of precipitation and temperature are considered minimal compared to lower precipitation and temperature. Perhaps Peltier was taking into account the vegetation that occurs when you have high temperatures and large amounts of precipitation, namely tropical forests, which reduce pluvial erosion with all the plant matter and root systems. Peltier may have considered these areas as having as much or less pluvial erosion as areas where precipitation was very low on an annual basis.

Mass movement is defined as areas where steep slopes and high annual precipitation cause the loosening and falling of large amounts of material. The graph is indicative of these areas of great amounts of rainfall and precipitation and also of lower temperatures, where the freeze thaw cycle has less of an effect, and of higher precipitation. Where the amount of precipitation is minimal, there is little mass movement occurring. Wind action is defined as areas where wind action, also considered mechanical weathering, by means of high wind speeds due to lack of precipitation or of high enough precipitation, and therefore a lack of vegetation to reduce wind speeds. The graph defines high annual temperature and precipitation as having less wind action due to high amounts of vegetation and moist soils, while low temperatures and areas with low precipitation are considered more vulnerable to wind action. Finally, the morphogenetic regions graph, which is more of a climatic and vegetative classification than a weathering graph, illustrates the various climate regimes that the temperature and precipitation annual means can describe. The actions of plants and the animals they support can have an effect on the weathering of any particular location to a lesser degree. The classifications for the Morphogenetic Regions are:

Selva – Wet and hot annually

Maritime – Wet and warm annually

Moderate – Less precipitation but still warm

Savanna – Lower amounts of precipitation but temperatures range from low to high annually

Semi-arid – Low precipitation amounts and warm to hot

Arid – Very little precipitation and hot

Boreal – Warm but cycles between freeze-thaw cycle and enough precipitation to nurture hardy vegetation

Periglacial – Freeze-thaw cycle is dominant and occurs often, and

Glacial – Freeze-thaw cycle less effective since temperatures stay very low year round.

Shafiei et al. [6] studied weathering and geomechanical properties of Alvand granitic rocks in western Iran. From the field and laboratory studies, robust linear relationships are found between the weathering degree of the tested samples and their geomechanical properties. Maghsoodi et al. [3] studied the rock weathering process on the zoning of the North-West of Iran by Peltier's models. Results showed that from 9 of the morphogenetic zones of Peltier's model, 5 regions have occurred, so that the greater part is semi-arid zone in north west of Iran. Zamani (2009) in his doctoral thesis studied central Elborze morphogenetic of Iran by Peltier's method. Fowler and Peterson [1] represented Peltier's weathering, erosion and climatic graphs using Geographic Information Systems (GIS).

Khanlari et al. [2] evaluated weathering processes effect on engineering properties of Alvand granitic rocks (west of Iran), based on weathering indices. In this research was focused on the assessment of relationship between weathering indices and uniaxial compressive strength. For this reason, some of the most important weathering indices are reviewed. The aim of this study is determine of the rate and types of weathering and morphogenetic zones Namak lake basin using climatic data and Peltier's graph.

## MATERIALS AND METHODS

The study area is located on longitude $48^0$ 28′ to $52^0$ 28′E and latitude $32^0$58′ to $36^0$28′ N (Fig. 1). This zone includes the southern slopes of the central Elburz up to the northern slopes of the southern heights of Kashan and Karkas, and from the eastern slopes of Zagros to Dasht-e-kavir. The size of area under study equals 92544 $km^2$, 42020 $km^2$ (45.4%) of which is mountain and 50524 $km^2$ (54.6%) consist of plains and lakes. Altitude ranges from 800 m around Namak lake to 4375 m in the Jajrood heights (Fig. 2). In this domain, there are 3 large and some small playas, which absorb the surrounding water (Namak Lake, Hoze Sultan and Mighan Kavir). The average of annual rainfall varies from lower than 150 mm in the southeastern parts to more than 600 mm in the northern heights (Figure 3). The average of temperature varies –3 - 18$^o$C (Fig. 4).

For this study first rain and temperature data of 32 synoptic stations from 1956 to 2005 were collected (Table 1) and import excel software. Then correlation between elevation and rain and temperature was calculated. By using topography maps was prepared digital elevation model (DEM) of basin in Arc-map. The rain and temperature of DEM cells calculated by above equations. The seven diagrams of Peltier was scanned in jpg format and reference based on rain and temperature. Total of DEM cells overlay on the graphs based on rain and temperature and then detected zones of cells. In order to use this information in Peltier seven models, the unit of temperature and precipitation changed from Celsius to Fahrenheit and from millimeters to inches.

## RESULTS AND DISCUSSION

The temperature gradient in relation to the height is: $T = 22.43-0.006H$ (1)

Where, T; is the average temperature of the point H (m above sea level). By Equation 1 and the DEM map a temperature map can now be prepared.

The relation between rain and height is: $P = 40.88+0.135H$ (2)

The rain map of the basin can now be drawn by Equation 2.

Rain and temperature of total cells of DEM map calculated by above equations. Then point map prepared with X and Y coordinates equal rain and temperature. Overlay this map on the seven Peltier's graphs showed condition of total cells. By this method seven maps were drawn in the name of: chemical weathering, frost action, weathering regions, pluvial erosion, mass movement, wind action and morphogenetic regions (Fig. 5).

Namak lake basin climate from east to west and from south to north and north-west change from hot to cold and from dry to wet. Elevation factor plays the major role in this change. Due to low average rainfall and high temperatures in the basin water balance is negative. Qualitative and quantitative water scarcity and reduce the plant cover has increased erosion by wind and water. Different faces of deep drainages, ditches and sand dunes at wider deployment are proof of the high water and wind erosion. Low humidity in the basin has reduced the mass movement and chemical weathering. Since the weathering rate is sum of chemical weathering and mechanical, weathering rates are low. In totally, basin due to climate conditions, most of the semi-arid and arid regions respectively morphogenetic zones basin belongs. Zones observed in basin include: maximum and moderate in wind action, very slight and slight mechanical in weathering, weak in chemical weathering, absent and weak in frost action, minimum and moderate in mass movement, maximum, minimum and moderate in pluvial erosion and arid, semiarid, savanna and boreal in morphogenetic regions.

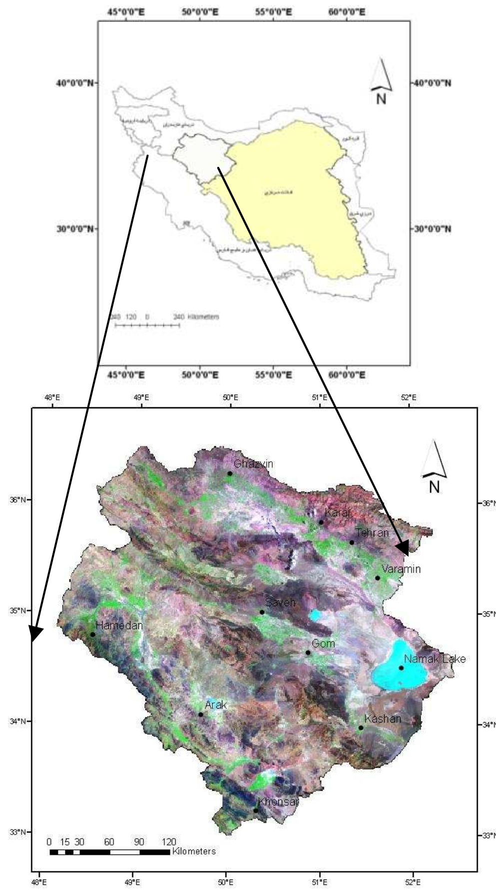


**Fig. 1: Basin of Namak lake**

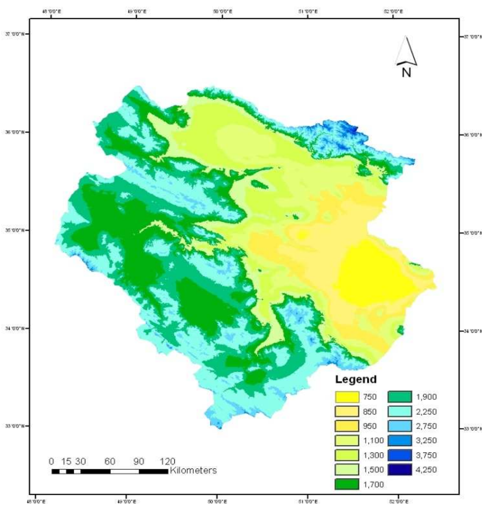


**Fig. 2: Hypsometry map of Namak lake basin**

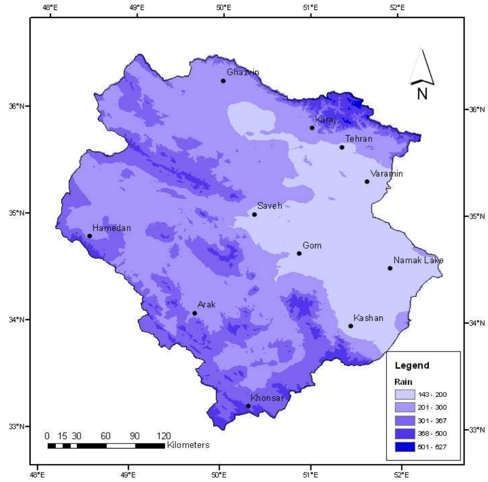


**Fig. 3: Rain map of Namak lake basin**

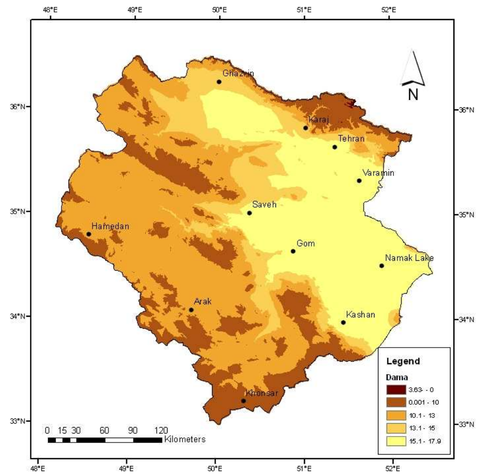


**Fig. 4: Temperature map of Namak lake basin**

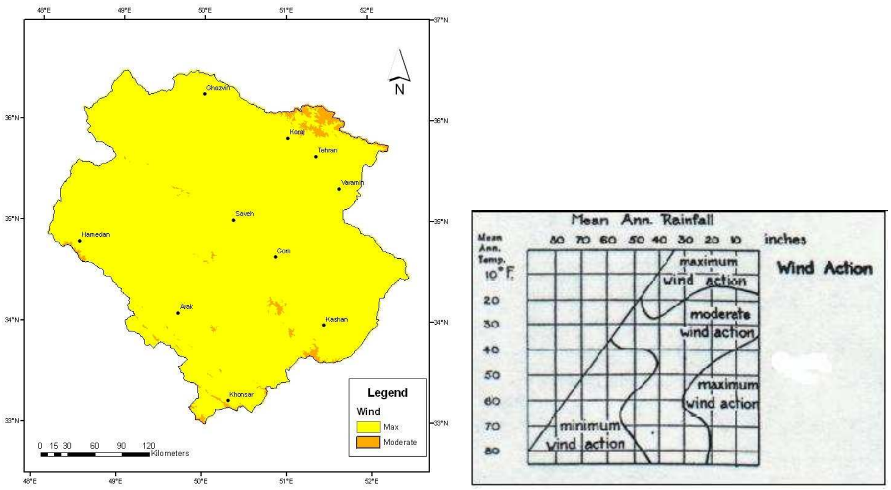


**Fig. 5: The Wind action map results from the processing of Peltier's graph**

**Table 1. Synoptic stations of Namak lake basin**

| Row | Station | Latitude | Longitude | Height (m) | Rain (ml) | Temperature (°C) |
|---|---|---|---|---|---|---|
| 1 | Arak | 49.77 | 34.1 | 1708 | 345.27 | 13.65 |
| 2 | Ardestan | 52.38 | 33.38 | 1252 | 104.82 | 17.4 |
| 3 | Avaj | 49.22 | 35.57 | 2034 | 345.52 | 10.24 |
| 4 | Brujerd | 48.8 | 33.9 | 1632 | 474.4 | 13.64 |
| 5 | Damane Feraidan | 50.48 | 33.02 | 2300 | 323.06 | 10.01 |
| 6 | Dargazin | 49.07 | 35.35 | 1870 | 329.53 | 10.74 |
| 7 | Dodahak | 50.63 | 34.06 | 1400 | 142.96 | 15 |
| 8 | Dushan Tape | 51.33 | 35.7 | 1209 | 254.77 | 17.52 |
| 9 | Duzaj | 49.82 | 35.4 | 2100 | 226.48 | 10.37 |
| 10 | Gakan Ashtian | 49.97 | 34.55 | 1741 | 282.51 | 12.96 |
| 11 | Garmsar | 52.27 | 35.2 | 825 | 123.54 | 17.58 |
| 12 | Ghazvin | 50 | 36.25 | 1278 | 318.85 | 13.88 |
| 13 | Golpayegan | 50.28 | 33.47 | 1870 | 249.01 | 12.95 |
| 14 | Gom | 50.85 | 34.7 | 877 | 157.66 | 18.03 |
| 15 | Hamedan | 48.53 | 34.85 | 1749 | 305.48 | 10.77 |
| 16 | Hamedan (Noje) | 48.72 | 35.2 | 1679 | 331.62 | 10.8 |
| 17 | Esfahan | 51.66 | 32.62 | 1550 | 118.1 | 15.9 |
| 18 | Karaj (synoptic) | 50.9 | 35.92 | 1312 | 272.8 | 13.5 |
| 19 | Karaj (Daneshkade) | 51.03 | 35.8 | 1321 | 240 | 14 |
| 20 | Kashan | 51.45 | 33.98 | 982 | 138.9 | 18.9 |
| 21 | Khonsar | 50.32 | 33.23 | 2300 | 352.9 | 11.7 |
| 22 | Khandab | 49.2 | 34.4 | 1742 | 331.2 | 15.8 |
| 23 | Khoramdare | 49.18 | 36.18 | 1575 | 309.6 | 10.9 |
| 24 | Malayer | 48.82 | 34.28 | 1725 | 309.3 | 13.31 |
| 25 | Natanz | 51.9 | 33.53 | 1684 | 143.8 | 14.7 |
| 26 | Save | 50.33 | 35.05 | 1108 | 202.2 | 18.2 |
| 27 | Shams Abad | 49.73 | 33.82 | 2400 | 341.3 | 11.5 |
| 28 | Tafresh | 50.03 | 34.68 | 1930 | 294 | 12.6 |
| 29 | Takestan | 49.65 | 36.05 | 1325 | 239.7 | 13.5 |
| 30 | Tehran | 51.32 | 35.68 | 1190 | 229.9 | 17.1 |
| 31 | Veramin | 51.65 | 35.31 | 1000 | 162.7 | 16.6 |
| 32 | Zanjan | 48.48 | 36.68 | 1663 | 304.2 | 11.1 |

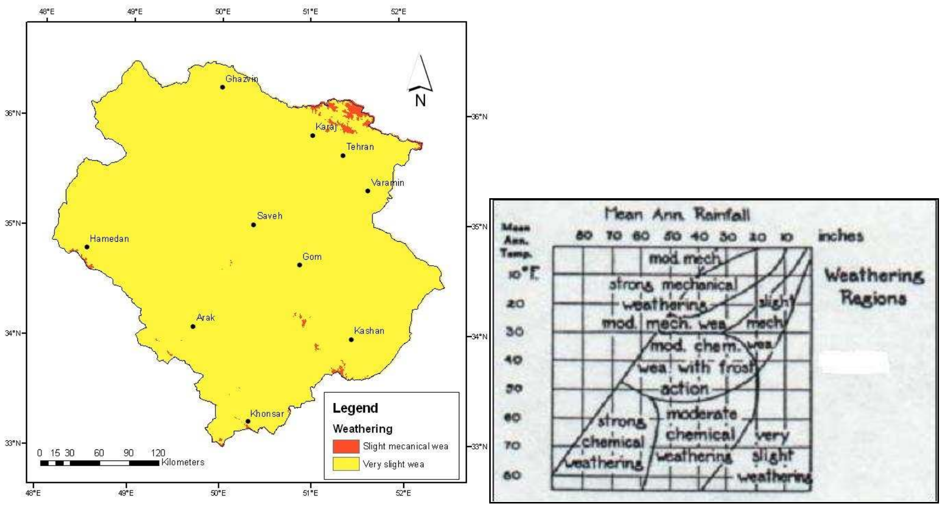


**Fig. 6: The weathering regions map results from the processing of Peltier's graph**

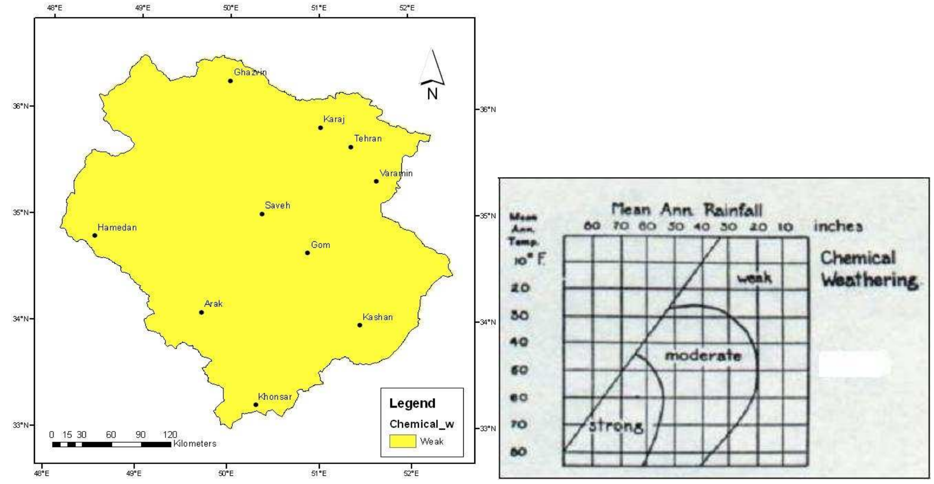


**Fig. 7: The chemical weathering map results from the processing of Peltier's graph**

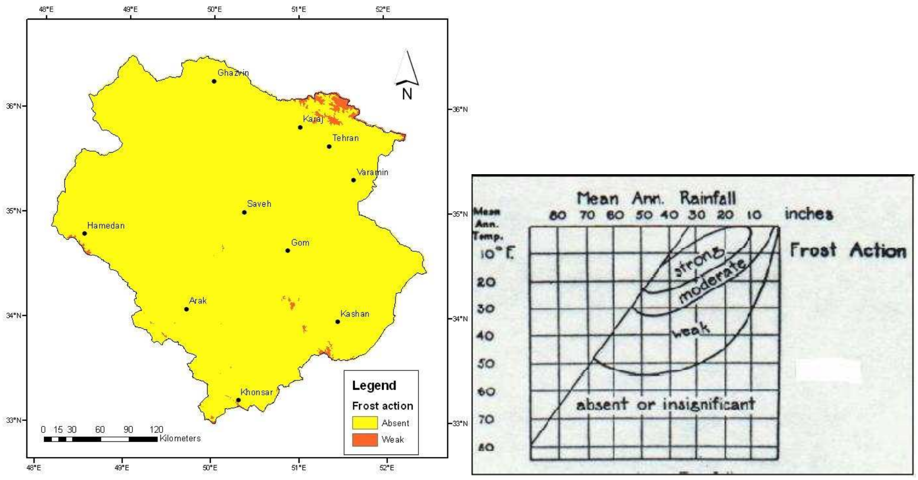


**Fig. 8: The frost action map results from the processing of Peltier's graph**

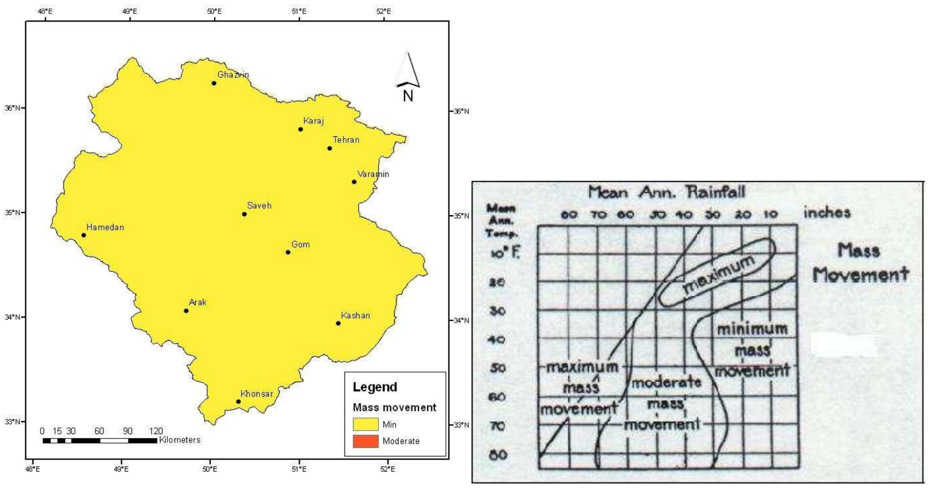


**Fig. 9: The mass movement map results from the processing of Peltier's graph**

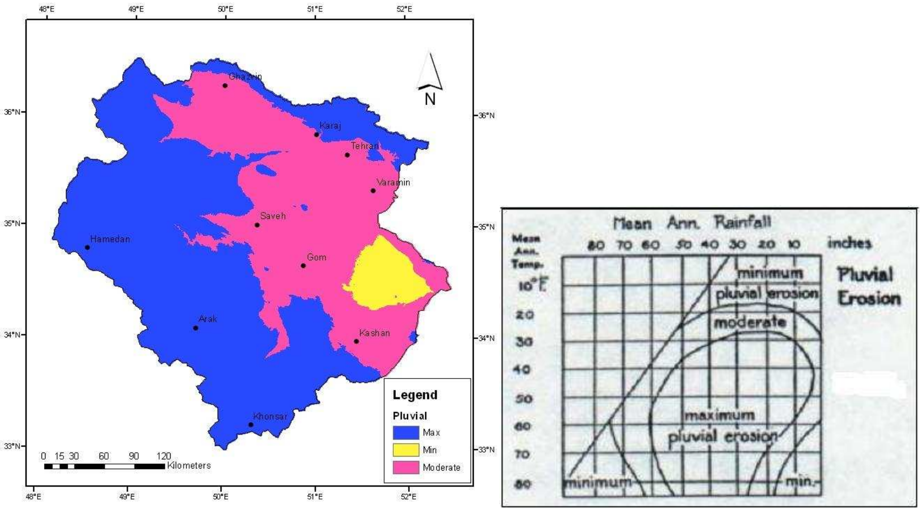


**Fig. 10: The pluvial erosion map results from the processing of Peltier's graph**

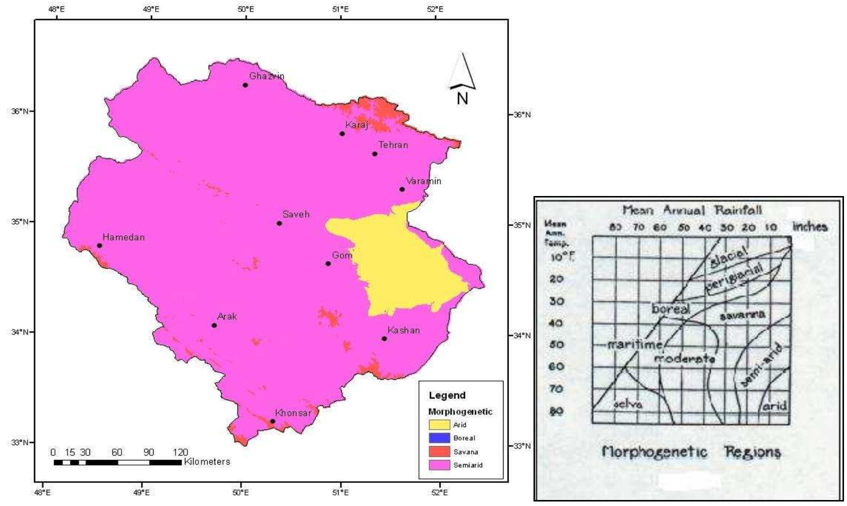


**Fig. 11: The morphogenetic regions map results from the processing of Peltier's graph**

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