Geophysical Research Abstracts
Vol. 14, EGU2012-6824, 2012
EGU General Assembly 2012

Integrated geomorphologic and GIS analysis for the assessment of erosion zones and its relationship with hazardous zones in the Zacatecas and Guadalupe quadrangles, Mexico

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The morphology of the Zacatecas and Guadalupe quadrangles is composed to the West by a NNE-SSW fault bounded range and to the East a valley cut by minor hills. The most important and fast growing cities in the state are located in that range. However, in urban development plans variables such as the geology and geomorphologic processes, as well as the land cover characteristics, are poorly taken into consideration. Due to the landscape modification the erosion agents, mainly water, removes loose materials that are either natural or artificial. The effects on the buildings and roads are fractures, slope instability, and rock falling.

In this study we present a model that considers the detailed geologic mapping, the geomorphology, land use, vegetation, and the digital slope model scale 1:50 000. The geomorphologic parameters considered were: relief energy, dissection density, general dissection density, and maximum dissection depth. The location and internal characteristics of mapped talus deposits were the basis to define the erosion criteria. High erosion zones are located in slopes over 20° where the talus deposits initiate due to the relative abundance of loose debris. Medium erosion areas are located in slopes over 10° that downslope has progressive accumulation of sediments. While the low erosion zones are located in slopes ranging from 5° to 20° with almost flat lying beds.

These parameters were analyzed in ArcGIS together with the digital slope model, detailed geology mapping, the land use cover, and the soil information. The results where verified in the range where the city has been growing in recent years. The soils all over the range are lithosols which are only 10 to 15 cm thick; while the vegetation is composed mainly of bushes and nopals. Even though both, vegetation and soil are not modified, the erosion effects in them are very slow regardless of their location.

The faults located in high erosion zones facilitate rock falling mainly during the rainy season; whereas in medium erosion zones it occurs if the road cuts or cliffs are steep. The rocks varying from loose to moderately consolidated, as well as the artificial fillings and talus deposits, are easily or difficultly eroded according with the erosion zones proposed in our model. The effects observed are fractured roads and house walls, removal of soil underneath the buildings, gullies formation, and slope instability.

The model defines areas where the erosion effects can be related to the development of hazardous zones. This model gives criteria for land use planning and urban development.