Micro-gravity measurements to constrain permeability in the Shale Hills Critical Zone Observatory

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The Shale Hills Critical Zone Observatory is a long-term research site with focus on the development of soil and regolith from the underlying shale bedrock. A zero-order stream drains the watershed, which has a stream valley with an average slope of 20% (18^{o}) on the north side of the stream and 32% (29^{o}) on the south side. Flow within the watershed is directed toward the stream and appears to be controlled, in part, by the thickness of the soil and regolith. The thickness of the weathered bedrock material (and thus the expected increase in permeability associated with this broken material) is not well quantified within the watershed. Here, we propose that increased permeability, directly related to an increase in porosity, should produce a decrease in density, which leads to a localized small gravity anomaly. However, since the maximum gravity anomaly predicted from this increased permeability may be as small as 0.03 mGal, the field conditions make the required precision a difficult target. To test the possibility of using gravity tools to help constrain permeability watershed-wide, we have collected high-resolution gravity data along the sides of the valley starting near the ridge and extending to the stream channel. The measurement procedure included acquiring data for 5 minutes at each station, which allowed for the 95% confidence limit of the average gravity to be calculated. The minimum 95% confidence limit on the data was 0.006 mGal which is less than the predicted gravity anomaly. The Bouguer anomaly values gradually decrease from the ridge toward the stream, with significance at the 95% confidence limits, implying that the thickness or porosity of the soil and regolith gradually increases from the ridge toward the stream. Modeling with constraints from invasive drilling at the ridge and stream provide characteristics of the increased permeability zone.