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Present-day stress state analysis on the Big Island of Hawai′i, USA

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We analyze and interpret the stress features from a c. 1.5 km deep fully cored borehole (PTA2) on the Big Island of Hawai′i within the Humu′ula saddle region, between the Mauna Kea and Mauna Loa volcanoes. The Big Island of Hawaii comprises the largest and youngest island of the Hawaiian–Emperor seamount chain and is volumetrically dominated by shield stage tholeiitic volcanic rocks. Mauna Kea is dormant whereas Mauna Loa is still active. There are also a series of normal faults on Mauna Loa's northern and western slopes, between its two major rift zones, that are believed to be the result of combined circumferential tension from the two rift zones and from added pressure due to the westward growth of the neighboring Kīlauea volcano.
The PTA2 borehole was drilled in 2013 into lava dominated formation (Pahoehoe and Aā) as part of the Humu′ula Groundwater Research Project (HGPR) with the purpose of characterizing the groundwater resource potential in this area. In 2016 two downhole logging campaigns were performed by the Operational Support Group of the International Continental Scientific Drilling Program (ICDP) to acquire a set of geophysical data as part of the Volcanic Margin Petroleum Prospectivity (VMAPP) project. The main objective of the logging campaign was to obtain high quality wireline log data to enable a detailed core-log integration of the volcanic sequence and to improve understanding of the subsurface expression of volcanic rocks. We identify stress features (e.g. borehole breakouts) and volcanic structures (e.g. flow boundaries, vesicles and jointing) at depth using borehole images acquired with an ABI43 acoustic borehole televiewer. We analyzed and interpreted the stress indicators and compared their orientation with the regional stress pattern. We identified a set of stress indicators along the hole dominantly concentrated within the lower logged interval of the PTA2 borehole. Two primary horizontal stress indicators have been taken into account: borehole breakouts (bidirectional enlargements) (BB) and drilling induced tensile fractures (DIF). BB and DIF occur when the stresses around the borehole exceed the compressive and tensile yield stress of the borehole wall rock respectively causing failure. A breakout is caused by the development of intersecting conjugate shear planes that cause pieces of the borehole wall to spall off. For a breakout to develop, the stress concentration around a vertical borehole is largest in the direction of the minimum horizontal stress. Hence, BB develops approximately parallel to the orientation of the minimum horizontal stress. For the DIF, the stress concentration around a vertical borehole is at a minimum in the maximum horizontal stress direction. Hence, DIF develop approximately parallel to the orientation of the maximum horizontal stress. Based on the World Stress Map, the present-day stress in this area is defined only by focal mechanism solutions. These data give a unique opportunity to characterize the orientation of the present-day stress field between two large volume shield volcanoes on an active volcanic island using a different approach and stress indicators.