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Assessing the Viability of Enhanced Geothermal Systems Development in the United States

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The successful implementation of Enhanced Geothermal Systems (EGS) technology has the potential to dramatically expand both the magnitude and spatial extent of geothermal energy production, and the U.S. Geological Survey (USGS) has been working to develop a comprehensive EGS resource assessment for the United States. However, a number of outstanding scientific and technical issues must be resolved in order to ensure the accuracy and reliability of this assessment. Among these are improving estimates of temperature in the upper crust to better quantify the thermal energy available at those depths viable for EGS reservoir creation, evaluating the likely heterogeneity of fracture permeability within EGS reservoirs and its influence on thermal energy recovery, and determining those conditions under which it is possible to replicate the high average permeability (approximately 10^{-15} to 10^{-13} m^2) characteristic of natural hydrothermal reservoirs. Although there are significant gaps in the spatial coverage of heat flow measurements in much of the United States and some uncertainty in the estimation of thermal properties at depth, analysis of the existing thermal data indicates that much of the western United States and large areas throughout the rest of the country will be suitable for EGS development in both crystalline basement and deep sedimentary basins. However, the expected heterogeneity of fracture permeability within EGS reservoirs developed at depth within low porosity rock may limit thermal energy recovery in crystalline basement to the lower end of the observed range for producing natural geothermal reservoirs. In addition, a survey of models for the development of fracture permeability from the shear slip along pre-existing natural fractures induced by hydraulic stimulation indicates that production from EGS reservoirs will be sensitive to the influence of effective stress and rock properties on the processes of shear fracture formation and closure. Calibration of model parameters with results from EGS field experiments and demonstration projects suggests that sufficient permeability may be difficult to attain through shear stimulation at depths greater than approximately 6 km, particularly in regions in regions of reverse faulting, which are characterized by high normal stress on pre-existing faults and fractures. Consequently, away from the margins of hydrothermal systems and areas of active volcanism which are characterized by anomalously high temperatures at shallow depths, some of the most promising targets for EGS development in the near term may be found in the deeper parts of sedimentary basins, where higher intrinsic porosity and permeability provide the basis for developing higher rates of fluid production. However, this preliminary interpretation is limited by the relatively small number of cases in which model predictions can be compared to laboratory or in situ data. The key challenge for improved EGS resource assessments is acquiring and

interpreting comprehensive laboratory and field data that can provide quantitative constraints on the recovery of heat from EGS reservoirs in diverse settings.