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Use of Gamma-ray and Spectral Gamma-ray log Data to Identify Primary Volcaniclastic Deposits in the Subsurface - Implications for Aquifer Characterization, Sutter Buttes, California

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Identification of distinct, genetically related stratigraphic packages in the subsurface using conventional water resource data sets (e.g. vague lithologic descriptions and sparse borehole geophysical logs consisting of spontaneous potential and resistivity) is difficult and often misleading. Natural gamma-ray (GR) logs record the total radioactivity emitted by sediments surrounding a borehole, and spectral gamma-ray (SGR) logs measure the contribution of radioisotopes, potassium (K), thorium (Th), and uranium (U). These logs permit a more refined interpretation of lithology and a proxy for determining depositional environments.

This study attempts to correlate subsurface strata penetrated by three test holes drilled in Sutter Extension Water District with strata exposed in the Sutter Buttes. Lithologic samples and borehole geophysical data (e-log with GR, and an SGR log) were collected from these test holes located southeast of the Buttes. The Sutter Buttes volcano produced two distinct pulses of volcanism in the early Pleistocene, an early phase of rhyolitic volcanism and a subsequent phase of andesitic volcanism. Each volcanic episode generated an apron of fluvial, debris flow, and pyroclastic deposits that are now covered by more recent alluvial sediments.

A distinctive, possibly diagnostic, increase or baseline shift in the GR signature occurred when primary volcaniclastics from the Buttes were encountered. The source of the distinctive GR signature was determined, using the SGR log, to be a pronounced increase in K and U, and a minor increase in Th. The SGR log also displayed a slight additional increase in the K concentration associated with rhyolitic fragmental material. These findings were substantiated by lithologic samples.

Sutter Buttes andesite and rhyolite exposures yield concentrations of K, and U that are two to four times higher than samples from overlying alluvial strata. The GR and SGR data suggest the Sutter Buttes volcaniclastics are also two to four times higher than the underlying Sutter Formation, which consists of reworked andesitic sediments probably equivalent to the Tuscan Formation. The lower concentrations of K and U in the Sutter Formation are attributed to fluvial reworking and incorporation of metamorphic detritus.

Integrating GR and SGR data with standard e-logs and lithologic data provides an effective way to identify and predict subsurface facies distributions and serves as a tool for regional correlation of genetically related strata, resulting in better characterization of hydrostratigraphic units.