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Checking Smectite Contents in Selected UGTA Samples From Pahute Mesa Phase I Wells

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In December 2010, Rick Warren pointed out the absence of smectite in samples of altered tuffs collected and analyzed from wells during the Phaute Mesa Phase II drilling. He mentioned that most samples from the Phaute Mesa Phase I wells contained smectite. He was concerned about the inconsistency of the mineralogical results of samples from the Phase II wells drilled in the same general area. Even though some of the samples contained minor amounts of smectite, the LANL team checked the XRD results of all samples analyzed from the Phase II drilling and concluded that the absence of smectite from some of the samples of altered tuffs was not due to analytical problems but probably due to water-rock interactions at different thermal and burial conditions. The LANL team proposed that representative samples from the Phase I drilling be selected for reanalysis using the same equipment and setting. Rick identified three samples from the ER-EC-1 (ER-EC-1 4320D, ER-EC-2A (ER-EC-2A 3720D), and the ER-EC-6 (ER-EC-6 1530D) wells and the original powders for each of the samples was sent to LANL from the UGTA sample repository at Mercury, Nevada, for quantitative mineralogical analysis. The same procedure used during the Phases I and II analyses were followed to prepare the samples. The powdered fractions of each of the samples were mixed with an internal standard of 1.0 μm corundum in a ratio of approximately 80% sample to 20% corundum. Samples were pulverized for approximately 10 minutes using acetone in a Brinkmann automated grinder to reduce the particle size and to homogenize the samples and internal standards. The samples were reanalyzed using the same equipment and setting. The quantitative XRD results showed no smectite except for weak signals of mixed layered illite/smectite in the three types of rock fragments handpicked from the ER-EC-6 1530D sample. Minor quantities (1 to 5 wt %) of smectite were reported in the original Phase I analyses in 1999 and 2000 (Table 1). The types and abundances of the Phase I minerals were consistent with the mineralogical compositions of the 2010 results. The absence of smectite did not resolve the issue why a small quantity of smectite was identified in the original analysis but absent from the current results.

Table 1. XRD results of altered tuff samples analyzed in 2010 (Hongwu Xu) and in 1999 (S.J. Chipera). Two-sigma uncertainties are given for the 1999 analyses by the internal standard (I) method. All analyses without uncertainties were by full pattern (F) method, those by SJC in 2000.

Sample	*Analyst*		*Clays*				*Zeolites*				*Felsics*				*Total*
		DM	*KA*	*CH*	*SM*	*MI*	*ZA*	*ZC*	*ZM*	*HM*	*QZ*	*FS*	*KF*	*PL*	*WW*
ER-EC-1 4320D	*2010*					*8.7*	*14.3*				*39.9*	*36.8*	*19.9*	*16.9*	*99.7*
ER-EC-1 4320D	*1999*				*5(2)*		*16(1)*				*47(2)*	*28(4)*			*96(5)*
ER-EC-2A 3720D	*2010*		*2.8*			*7.5*				*0.3*	*30.0*	*59.2*	*41.2*	*18.0*	*99.8*
ER-EC-2A 3720D	*1999*	*0.9*	*2.1*		*2.9*	*1.2*				*0.4*	*30.0*	*56.5*	*44.6*	*11.9*	*94.1*
ER-EC-6 1530D	*2010*		*2.6*			*6.1*		*3.0*		*0.3*	*36.4*	*51.1*	*34.7*	*16.4*	*99.5*
ER-EC-6 1530D	*1999*			*0.25 (0.25)*	*1(1)*	*0.25 (0.25)*		*1(1)*	*1(1)*	*0.25 (0.25)*	*55(3)*	*41(6)*			*99.75 (6.94)*

The minerals consist chlorite of (CH), hematite (HM), dolomite (DM), feldspar (FS), kaolinite (KA), K-feldspar (KF), Mica/illite (MI), plagioclase (PL), quartz (QZ), smectite (SM), analcime (ZA), clinoptilolite (ZC) and mordenite (ZM).

The LANL team proposed to conduct simple experiments on three of the samples to extract the clay-size fractions, using standard sedimentation processes. The mineralogy of the fine fraction was determined for comparison with the results of the bulk samples. The original bulk powders for the three samples were consumed during the second round of quantitative XRD analyses. Additional bulk samples were requested and received from Sig Drellack of NSTec in Las Vegas, Nevada, on January 28, 2011 to conduct the experiment. Each of the samples was carefully checked for homogeneity using a binocular microscope before they were pulverized for the clay-size separations. The drill cuttings for the two samples (ER-EC-1 4320D and ER-EC-2A 3720D) were generally pure except for few contaminants that were removed during the screening of the samples. The third sample (ER-EC-6 1530D) contained at least three types of rock fragments based on the texture and color of the various fractions. Sample ER-EC-6 1530D consisted of pinkish orange (ER-EC-6 1530D-A), gray (ER-EC-6 1530D-B), and pinkish gray (ER-EC-6 1530D-AC) rock fragments and each fraction was carefully handpicked and pulverized. The clay-size fractions were extracted by sedimentation process using deionized water.

Each of the sample powders was added to about 600 ml of deionized water and mixed using a Branson ultrasonic probe for 14 minutes to disaggregate the samples in the solution and extract the clay-size fractions. The homogenized solution was placed on a stable counter top for an hour. The suspension (<2 µm) was decanted into clear plastic bottles for clay-size separations using a DuPont Sorval super-speed angle-rotor centrifuge for a spin time of an hour. After an hour the bottles were removed and the clear solution was decanted. The residue at the bottom of the bottle was extracted using deionized water. The same procedure was applied for the other four samples and the clay-size fractions extracted accordingly.

The coarser (>2 µm) and clay-size (<2 µm) fractions were transferred to evaporating dishes using deionized water and placed on a warm hot plate for drying. The same size fractions were obtained from the ER-EC-2A 3720D and from the ER-EC-6 1530D-A, -B. and -C powders. No other fraction finer than the <2 µm was obtained from any of the samples. After the samples dried, the <2 µm fractions were processed for determining the mineralogical compositions of the five samples using the quantitative XRD method. The clay-size fractions (<2 µm) of each of the samples were mixed with an internal standard of 1.0 µm corundum in a ratio of approximately 80% sample to 20% corundum. The mixture was grinded for approximately 10 minutes using acetone in a Brinkmann automated grinder to reduce the particle size and to homogenize the samples and internal standards. The mineralogical compositions of the finer (<2 µm) fractions were determined using the same parameters and equipment as in the Phase I and II analyses. The results of the analyses are given in Table 2.

Table 2. Mineralogical compositions of the bulk and clay-size (<2 µm) fractions of samples from the Phase I Pahute Mesa drilling.

Sample	Kaolinite	Analcime	Smectite	Mica/Illite	Clinoptilolite	Mordenite	Hematite	Quartz	K-Feldspar	Plagioclase	Total
EREC1-4320D	---	14.3	---	8.7	---	---	---	39.9	19.9	16.9	99.7
EREC1-4320D (<2µm)	---	12.1	---	42.5	---	---	---	18.1	17.0	11.8	101.4
EREC2A-3720D	2.8	---	---	7.5	---	---	0.3	30.0	41.2	18.0	99.8
EREC2A-3720D (<2µm)	5.4	---	---	13.5	---	---	0.3	17.7	41.4	19.6	97.9
EREC6-1530D	2.6	---	---	6.1	3.0	---	0.3	36.4	34.7	16.4	99.5
EREC6-1530D-A (<2µm)	6.1	---	---	15.5	4.4	---	0.2	32.0	33.2	7.2	98.5
EREC6-1530D-B (<2µm)	10.1	---	---	21.2	6.1	---	0.1	31.3	24.5	6.7	100.0
EREC6-1530D (<2µm)	8.4	---	---	11.4	4.1	---	0.1	38.1	30.4	7.4	99.9

Results

As expected the clay-size fractions contained no smectite consistent with the results of the quantitative XRD analyses of the bulk samples in 2010 except for weak signals of mixed layer illite/smectite in sample ER-EC-61530D. As shown in Table 2, the clay-size separations (<2 µm) significantly increased the mica/illite and kaolinite contents of the five samples. In contrast, the felsic mineral contents in the same size fractions substantially decreased.

Conclusion

Despite minor smectite in the original analysis of the three samples from the Phase I drilling, the recent results from the 2010 and 2011 investigations showed no smectite. The compositions of the clay-size fractions separated from the bulk samples of the Phase I drilling and the new results of more than 140 samples of cuttings and 1-inch cores of altered tuffs from the Pahute Mesa

Phase II drilling, suggest that the results from the just completed quantitative mineralogical analyses were accurately determined.