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Preliminary Report on Drilling in and Near the
San Andreas Fault Zone: Dry Lake Valley No. 1

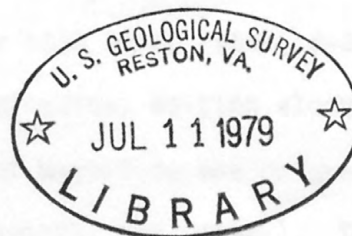
[Reports - Open file series]

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This report is preliminary and has not
been edited or reviewed for conformity
with Geological Survey Standards and
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Introduction

The purpose of drilling into the San Andreas fault zone is threefold. First, recovery of material from depth will permit determination of the composition and constitutive properties of both solid and fluid phases. Second, it will enable measurements of the physical state of the fault zone to be made (that is, the state of in-situ stress, pore pressure, and temperature). Finally, it will allow emplacement of instruments at depth in the fault zone as part of experiments related to earthquake prediction.

This report briefly describes the drilling history and preliminary analysis of fault zone materials from site Dry Lake Valley (DLV) No. 1 (Fig. 1). The site is located at Lat. $36^{\circ}28.09'N$, Long. $121^{\circ}03.32'W$. This site was chosen in an attempt to drill a 1 km deep well that would reach earthquake foci. Although the entire central section of the San Andreas fault is characterized by moderate seismicity and aseismic creep, Dry Lake Valley has particularly shallow earthquakes as well as a fairly high creep rate (18-20 mm/year, S. Schultz, pers. comm.). Fig. 2 is a longitudinal section along the San Andreas fault showing high precision locations of magnitude one or greater earthquakes that occurred in 1973-1975 (from W. Ellsworth, per. comm.). The depth accuracy of the earthquakes shown is about ± 0.5 km, and it is obvious from Figure 2 that Dry Lake Valley earthquakes are extremely shallow.

As shown in Figure 1 the general geology of the central section of the San Andreas fault consists of Tertiary to Jurassic sedimentary and volcanic rocks overlying Cretaceous age Gabilan granite of the Salinian Block on the west side of the fault and Cretaceous-Jurassic sedimentary assemblages of the Franciscan Complex to the east of the fault. Dibblee (1979) summarizes the

geology along the central San Andreas fault. At the Dry Lake Valley site as much as 2 km of Pliocene-Miocene marine sediments (Etchegoin and Santa Margarita formation) overlie Franciscan rocks on the northeast side of the San Andreas fault. On the southwestern side of the fault, 1-2 km of Pliocene-Miocene valley sediments and granitic conglomerate overlies the Gabilan granite.

Drilling Record

Drilling of DLV #1 was terminated when natural gas was encountered at a depth of about 387 m. As shown in Table I, drilling was primarily in clay gouge with assorted shows of shale, silt, and limestone in the cuttings. The cuttings were never indicative of an intact rock unit but rather consisted primarily of clay gouge with minor amounts of rock in the cuttings. Below 122 m considerably more shale was encountered in the cuttings, and some 2-3 m intervals contained distinctly more silt. Chert cuttings were observed in the gouge from the bottom of the well.

No particular drilling difficulties occurred. The drill stem once became stuck when circulation was temporarily lost at 290 m. Wash over pipe successfully freed the drill stem and drilling continued without incident. An unusual phenomenon occurred several times as the pipe was tripped out of the hole. The bit plugged with clay even though a float (check-valve) was used above the bit to prevent in-flow and there was no indication of plugging as drilling was underway.

Preliminary Clay Analysis

Samples were obtained by side wall coring at 4.6 m intervals from depths between 33.5 m and 284.7 m. Recovery was quite good and numerous intact cylindrical samples, 2.5 cm in diameter and 5.0 cm long were obtained. The samples were primarily (< 80%) composed of clay gouge. Selected samples were analysed for composition using x-ray diffraction techniques.

Samples were prepared in accordance with established methods (J. A. Bartow, pers. comm.; Gibbs, 1971). The procedure for quantitative analysis was taken from Schultz (1964) and is based on measurement of peak heights and areas. Results of the analysis are tabulated in Table II. It should be noted that quantitative estimates such as these are highly method-dependent but the relative amounts shown have been reproduced by at least one other method (R. Fournier, pers. comm.).

As shown in Figure 3, the predominant clay minerals found were montmorillonite and kaolinite. Illite and chlorite are also present but composed a considerably lower percentage of the samples. No mixed layer changes were found. A marked decrease in montmorillonite (and increase in kaolinite) occurs below 100 m. The reason this occurs is not clear.

Discussion

If it is persistent to considerable depths, the presence of clay gouges in the San Andreas fault has considerable significance with respect to the fault's mechanical behavior. Wu et al. (1975) discuss the distribution of clay gouges in the San Andreas fault system. They suggest that the origin of the clays is hydrothermal alteration of country rock and argue (after Waters

and Campbell, 1935) that the origin of such clays is probably not shallow. It can also be argued that the presence of clays in the fault zone at Dry Lake Valley is due to the presence of clay bearing Miocene sediments (I. Barnes, pers. comm.). If this were the case, one would not expect the clays to persist to depths greater than about 2 km, but the mechanism by which the clays in the sediments become concentrated in the fault zone has not been identified.

The occurrence of hydrocarbons at the Dry Lake Valley site was not totally unexpected as a small oilfield exists along the San Andreas fault at Bitterwater, only 11 km southwest of the drill site. At Bitterwater, however, oil production is from an upper Miocene arkose (at a depth of about 500 m) that has been deformed into an anticlinal flexure adjacent to the west side of the fault. The fault zone provides an impervious barrier to eastward migration of the oil. No gas is commercially produced at Bitterwater. Because at Dry Lake Valley drilling was within the impervious fault zone, the natural gas was probably concentrated in an isolated permeable zone. As the gas blew the drilling mud out of the hole, pressure in the zone exceeded hydrostatic pressure by at least 10%. The size of this zone, however, and whether the producing zone is similar in origin to that at Bitterwater, is not known.

References

- Dibblee, T. W., 1979, Geology along the San Andreas fault from Gilroy to Parkfield: U.S. Geological Survey Open File Report, in press.
- Gibbs, R. J., 1971, X-ray diffraction mounts, in Procedures in Sedimentary Petrology: John Wiley and Sons, Inc., New York, 653 p.
- Schultz, L. G., 1964, Quantitative interpretation of mineralogical composition from x-rays and chemical data for the Pierre Shale, in Analytical Methods in Geochemical Investigation of the Pierre Shale: U.S. Geological Survey Professional Paper 391-C, p. C1-C31.
- Waters, R. C., and C. D. Campbell, 1935, Mylonites from the San Andreas fault zone: American Journal of Science, v. 29, p. 473-503.
- Wu, F. T., L. Blatter, and H. Roberson, 1975, Clay gouges in the San Andreas fault system and their possible implications: Pure and Applied Geophysics, v. 113, p. 87-95.

Table I

Dry Lake Valley No. 1

Preliminary Sample Description from Cuttings

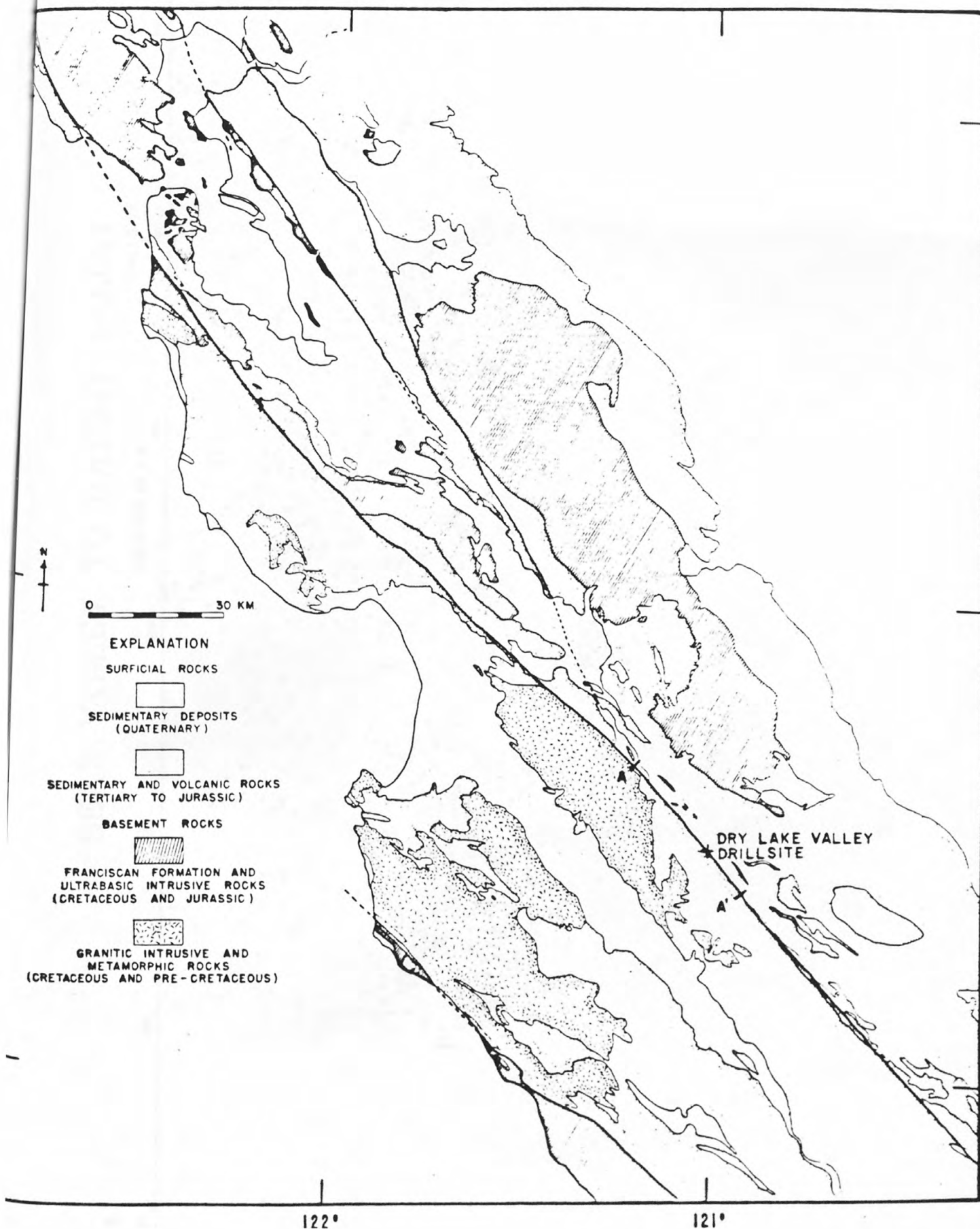
0 - 30 m	Brown clay, with very fine to fine quartz grains (some oxidized), and biotite.
30 - 372 m	Blue-gray clay with some shale in cuttings; several silty and limey 2-3 m intervals
372 - 387 m	(No samples)
387 m	Similar to blue-gray clay above but gray chert appears in cuttings.

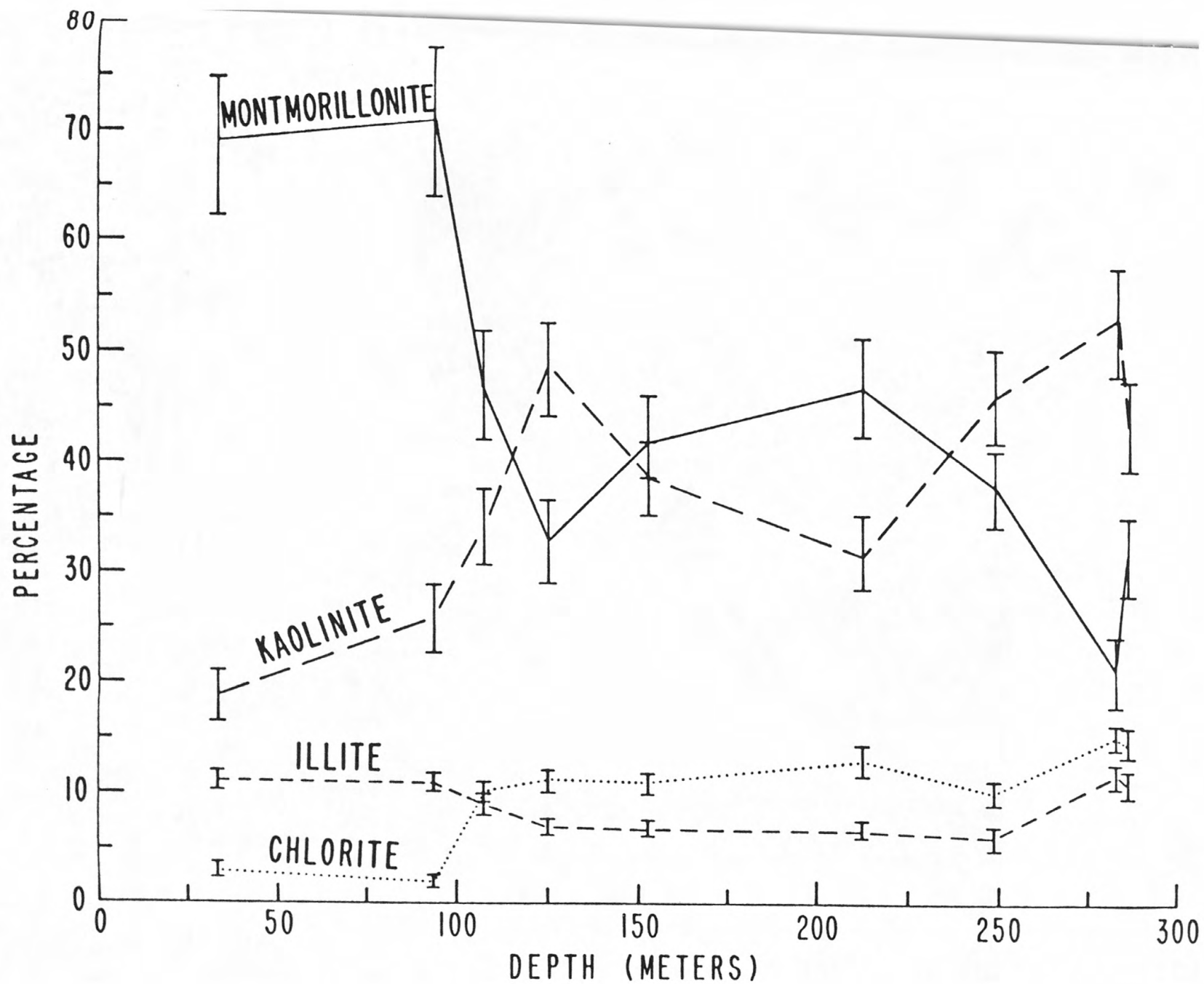
Table II
Dry Lake Valley Hole No. 1
Composition of clays by percentages

Depth (m)	Montmorillonite	Kaolinite	Illite	Chlorite
33.5	69	19	11	3
93.0	71	11	26	2
106.7	47	34	9	10
125.0	33	49	7	11
152.4	43	39	8	11
211.8	48	32	8	13
248.4	38	46	6	10
282.6	21	53	12	16
284.7	32	42	11	15

Figure Captions

- Figure 1: Generalized geologic map of central California showing location of Dry Lake Valley drill site. Section A-A' along the fault is shown in Figure 2.
- Figure 2: Longitudinal section along the San Andreas fault showing precise earthquake locations (W. Ellsworth, pers. comm.) and drill site. Accuracy of hypocentral depths is ± 0.5 km.
- Figure 3: Relative percentage of clay constituents as a function of depth in Dry Lake Valley well #1.





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