ACNWC-0020

MEMORANDUM

TO: Richard Major, Chief
Nuclear Waste Branch

FROM: Kenneth Foland, ACNW Consultant

SUBJECT: Report and Comments addressed to the ACNW

DATE: February 20, 1994

This memorandum is intended for the Advisory Committee on Nuclear Waste for the purpose of conveying comments and observations related to field excursions and discussion earlier this month in the vicinity of Yucca Mountain in Nevada.

On Monday January 31, I joined the site tour (along with Drs. Hinze and Pomeroy and Ms. Deering) that visited the Ghost Dance and Sundance faults and also Solitario Canyon trenches. On February 1 and 2, I (along with Hinze and Deering) attended the DOE-NRC site visit for the Erosion Topical Report topics led by John Whitney and Charles Harrington. On February 3, I went on the related trip led by Roger Morrison and Martin Mifflin that dealt with related issues. Several pages (total 6) are attached for the files; these are from the latter trip.

My comments below are given essentially in a chronological order. They are intended to address only some of the major points in terms of my view of the discussions and field relations seen.

- The surface expressions of the Ghost Dance and Sundance faults in the Yucca Mountain region are being defined in selected areas by Rick Spengler and associates. The detailed mapping appears to be documenting the fault zones that may have broad impact on the suitability of the proposed repository.

  Data were presented showing that these faults have magnetic signatures which suggests that properly designed geophysical surveys should be capable of supplying vital information on the location and extent of these fault zones in a very efficient manner. However, it was not clear exactly what further research is being planned by DOE.

- Trenching in Solitario Canyon by Alan Ramelli and associates is defining the history of recent observable fault motions. The associated soils are highly developed which was taken to indicate that they are several hundreds of thousand years old. However, there are apparently no actual age data for these deposits so that this does not seem to be well estab-

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lished. In order to define the timing relative to the antiquity of the soils and permissible times of fault motion, U series dates are urgently needed. Furthermore, there was much speculation about in-filled volcanic ashes in terms of indicating both an "old" (e.g., 100+ ka) eruption and also later, possibly a very "young" event (e.g., 5 ka). Clearly, the implications of timing are very important; it was not clear exactly what is planned for studying these deposits.

- On the DOE-NRC trip (both days), there was continuing and extensive discussion of the rock varnish cation ratio (VCR) dating. This approach continues to be quite controversial for several reasons (e.g., method of varnish formation and factors controlling its development, calibration, methods of application).

  In the Yucca Mountain area, Chuck Harrington and John Whitney have conducted careful sampling (deliberately biased) and obtained estimated ages which indicate that some colluvial boulder deposits are quite "old," in some cases exceeding a million years. These dates form a basis for concluding that the Yucca Mountain surfaces have been quite stable. Some trip participants hold that the estimated ages may be too old by a factor of 10.

  It seems to me that if the VCR method is going to be acceptable, considerable research is required to refine the underpinnings. Without this, it appears that any "ages" obtained using the current methodology are going to be the subject of considerable uncertainty and debate. There is a dearth of age determinations by other methods which might give confidence to the VCR estimates.

- It seemed to me that their was convincing evidence presented indicating that the surfaces have been stable. One line of evidence is the well-developed calcic soils, for example, seen in Solitario Canyon and on the flanks of Little Skull Mountain. Unfortunately, there seems to be very little actual age data (e.g., U series) on these materials; the age estimates appear to come from literature estimates based on other localities. Dates are urgently needed on the calcic soils to support their proposed antiquity.

- While calcic soils are seen well developed at the two localities mentioned above, I can't remember seeing any that are on the eastern slopes of Yucca Mountain. It seems possible from simple drainage considerations that the amount of runoff and rate of incision may be much greater on the eastern slope.

- In summary, the careful and in some instances detailed studies by Whitney and Harrington and associates that imply (on

several accounts) that the surfaces in the Yucca Mountain region have been stable and the landscape not dramatically changed in more that the past 100 ka. They need to solidify the age estimates, in my opinion, if there is going to be any consensus on this.

- The Morrison-Mifflin led trip dealt with selected features of the Tecopa basin and Amargosa Desert in the context of their implications for erosion in the Yucca Mountain area and the conclusion of the Topical Report. I think that three main points were made in this regard: (1) good evidence of extensive erosion and deposition is seen in the Tecopa Valley over the past approximately 160 ka; (2) well developed calcic soils may develop much faster than implied for Yucca Mountain localities; and, (3) rock varnish may develop at a much faster rate than proposed.

  Point (1) would seem to be well taken in terms of the geological features in Tecopa Valley. However, the implication of such features in the valley for Yucca Mountain are not obvious.

  Morrison pointed out calcic soils that were highly developed and, on the basis of a few U-series dates, must be less than 150 ka. Their are two major uncertainties that prohibit firm extrapolation of this finding to Yucca Mountain: (a) it is not clear exactly how well the surfaces are dated, inasmuch as the dates are limited and only 4 of the 12 obtained in the study made "sense"; and (b) there is a very high abundance of limestone and dolomite gravels and boulders (in contrast to Yucca Mountain), so that the rate of soil development may be much faster here.

  With respect to point 3, Jay Quade led the trip for the final two stops in the Indian Springs area. At both, quite extensively varnished small boulders sat atop interlocking pavements whose ages are well constrained to be less than about 10 ka. The implication is that varnish may develop quite rapidly. Harrington and Whitney pointed out that these varnishes are different and frequently develop at ground lines on small boulders. In fact, they have analyzed materials from one stop and found that the proper varnish yields a cation ratio consistent with a very young age.

- As a final point, I'd like to address briefly concerns the expectations of such DOE-NRC technical exchanges concerning DOE reports in terms of addressing key issues. This is the second one I've attended in past year, the other being "draft" report on volcanism late last spring. At both sessions there has been considerable disagreement among the various parties. My question is: how efficiently are the main points being addressed in a satisfactory and timely manner?

ITINERARY

Regional Evidence for Age of Landforms, Cyclic Erosion
February 3, 1994

(Detailed handouts on stops are separate)

Overnight February 2 in Pahrump, Nevada (Saddles West)

7:00 a.m.	Meet in front of Saddles West.
7:10 a.m.	Leave, travel west towards Shoshone, California, on Nevada Highway 372 which turns into California Highway 178.
7:30 a.m.	Turnoff for Stop 1 (to Chappo Spring). #1 geomorphic surface and 160 ± 10 ka ash.
9:00 a.m.	Return to Highway 178, west to Stop 2. View of Lava Creek B and Bishop tephras along the way.
9:15 a.m.	Stop 2, Shoshone Town Dump. #1 geomorphic surface, dates on BK soil horizon..
9:45 a.m.	Back to Highway 178, south on Highway 127 to Stop 3.
10:30 a.m.	Stop 3, 2/3 mile traverse by foot to #2 geomorphic surface, fault zones, geomorphic surface #1, coarse gravels of this surface.
12:30 p.m.	Lunch at this site (will carry makings/beverages).
1:00 p.m.	Leave to travel north on Highway 127 to Death Valley Junction, continue north to turnoff near Stateline to Fairbanks Spring (northernmost spring of Ash Meadows group).
2:00 p.m.	Stop at Fairbanks Spring. Discuss age relationships, compare landforms and apparent histories of Tecopa basin and Amargosa Desert.
2:30 p.m.	Leave, continue east to Crystal, then to U.S. 95 and on to the Indian Springs area.
("Stop 1" attached) 3:30 p.m.	Stop briefly to review desert varnish on gravels near Indian Springs (stop optional depending on time).
("Stop 2" attached) 4:00 p.m.	Continue southeast to Corn Creek badlands stop. Relationship of terrace gravels inset into well dated 7-9 ka paleodischarge deposits with well developed varnish on the desert payments of the gravel terrace. This is a key locality where available time for varnish formation is constrained to less than 9,000 years.
6:30 p.m.	Arrive in Las Vegas.

see handout of Jay Quade.

landform.doc

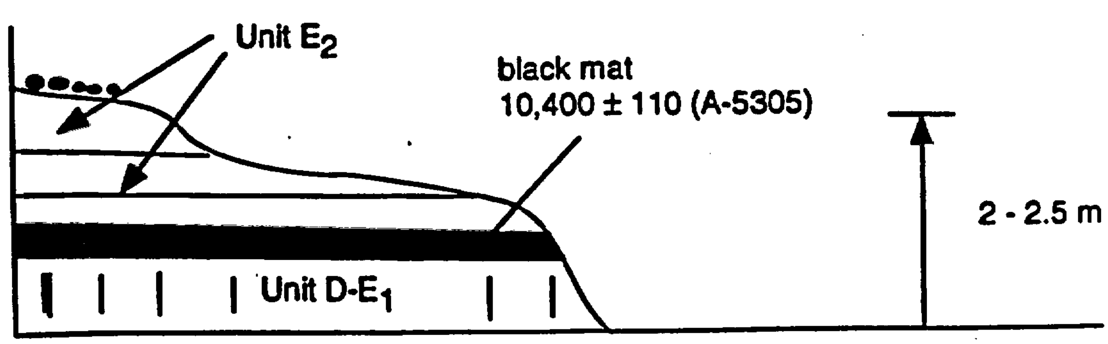
handout of Jay Quade

Quade 1

Stop 1 Indian/Cactus Springs Black Mat **Thursday, Feb. 3, p.m.**

At this stop we can view the relationship between an organic mat or "black mat" and the overlying alluvial unit capped by a typical early Holocene desert pavement. The black mat and many of the other buff-colored units north of the highway formed in association with vigorous spring discharge over much of the Indian Springs/Cactus Springs area during the late Pleistocene. The humate fraction in the mat has been dated to 10,400 ± 110 ^{14}C yrs B. P. A greenish clayey mudstone (Unit D-E_1) underlies the black mat; this unit was deposited in full-to late-glacial ponds and wet meadows in the area. The brown silt (Unit E_2) overlying the mat is undated at this location but can be recognized in other areas where it spans the early Holocene (and dates to 8500 to 7200 B. P. at the top of the silt). The interlocking desert pavement we see developed on top of the brown silts started to form not before about 8500 B. P. The deep dissection of the buff-colored sediments in the area and visible north of the road is therefore a mid-to late Holocene event. This sequence of events and ages is repeated in the surficial record of many valleys in southern Nevada.

Indian Springs - Roadside Exposure



Quade 2

Stop 2 Corn Creek "Narrows"

The fine-grained sediments exposed in the Corn Creek Narrows contain a fascinating record of spring discharge, alluvial filling and erosion, and extinction of Pleistocene megafauna (mammoth, horse, and camel). Most importantly, the stratigraphic relationships in the area illustrate how quickly interlocking, well-varnished desert pavements form, and how extreme the erosion has been on Corn Creek Flat in the last, roughly 8000 -7000 ^{14}C years.

We will discuss and visit all the key exposures and the relationships they illustrate. As background, the sequence of events recorded in these outcrops are (and see accompanying figures):

post-28,420 ± 1080/-950 to ~15,000 (?) B. P.: vigorous spring discharge feeds a marsh and perennial channel that flows through the narrows. Gradually aggrading system (Unit D); sage-piñon-juniper cover; mammoth, mastodon, camel, horse, and Pleistocene lion frequent the flowing creek.

15,000 (?) to 14,040 ± 320: drying period, weak soil (S_2 develops)

14,040 ± 320 to 10,980 ± 270: (Unit E_1) new channels cut, stream flows again, but marsh and spring discharge diminished, megafauna still present but disappear toward top of Unit E_1.

10,980 ± to about 8500/7200 B. P.: renewed channel cutting and spring discharge; black mats common across Corn Creek Flat and other valleys followed by aggradation of brown silts and finally gravel (Unit E_2); sage-piñon-juniper cover; megafauna gone.

post-8500/7200 B. P.: vegetation in region replaced by modern Mojave desertscrub; down cutting and deflation begins, continues in some areas today. The dissected badlands around you have all formed since about this time.

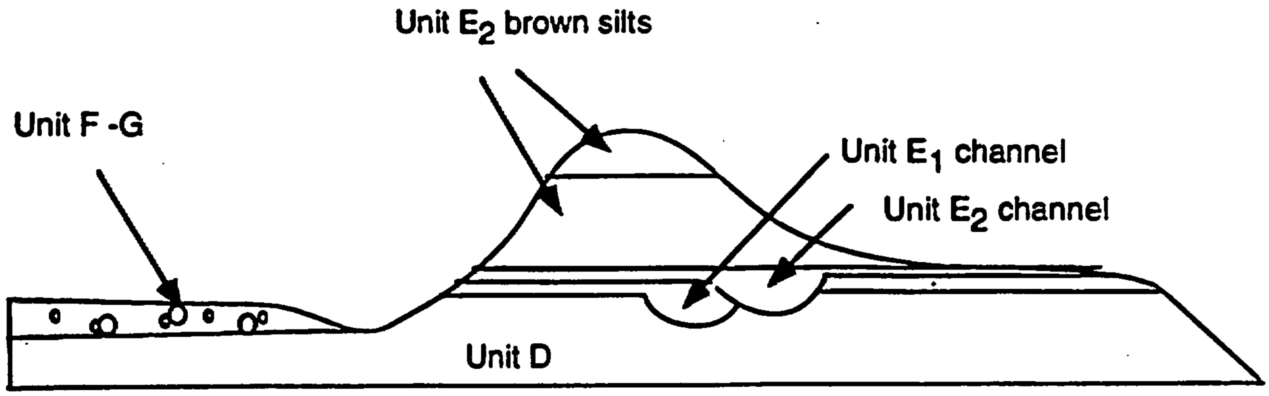
mid-Holocene (~6000 to 5000 B. P.): Local backfilling by silts (Unit F) higher on Corn Creek Flat, and surrounding alluvial fan surfaces stabilize briefly.

late Holocene - renewed erosion in most areas, continues today.

Three to 4 m (and locally up to 5 m) of erosion has occurred over much of the flat since the beginning of the mid-Holocene.

Quade 3

Schematic Stratigraphic Section, Corn Creek "Narrows"

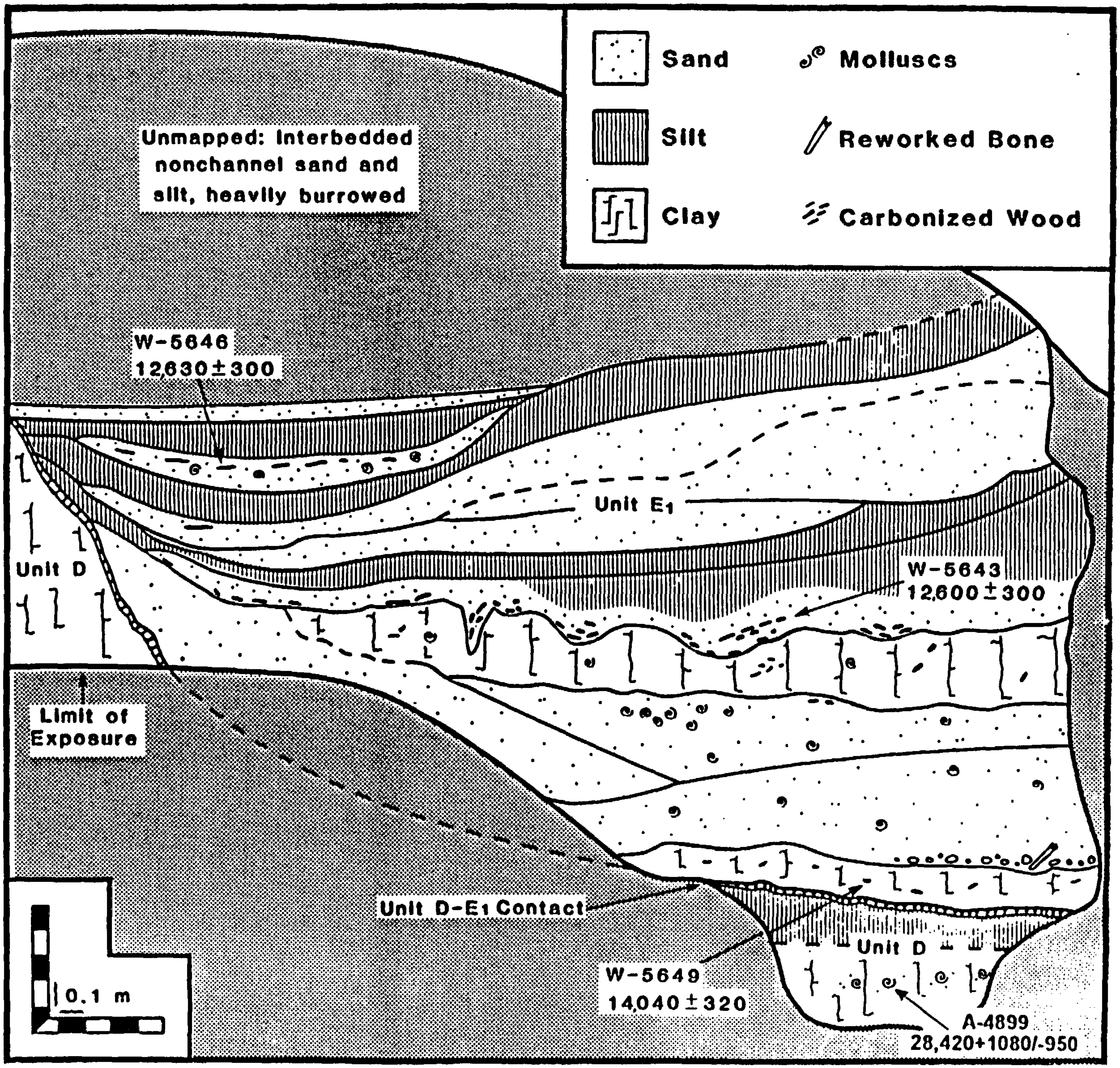


Unit F-G: mid- to late Holocene

Unit E_2: 10,980 - 7200 (?) ^{14}C B. P.

Unit E1: 14,040 - 10,980 ^{14}C B. P.

Unit D: pre-14,040 (~full-glacial)



Sand
Silt
Clay
Molluscs
Reworked Bone
Carbonized Wood
Unmapped: Interbedded nonchannel sand and silt, heavily burrowed
W-5646
12,630±300
Unit E1
Unit D
W-5643
12,600±300
Limit of Exposure
Unit D-E1 Contact
0.1 m
W-5649
14,040±320
Unit D
A-4899
28,420+1080/-950

Quade 4

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Spring-related carbonate rocks, Mg clays, and associated minerals in Pliocene deposits of the Amargosa Desert, Nevada and California

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ABSTRACT

The Amargosa Desert of Nevada-California is a spring-fed structural basin containing large amounts of Pliocene carbonate rocks and Mg clays deposited in playas, marshland, ponds, and flood plains. Pliocene basin-fill deposits dated at 2.4 to 3.2 Ma are subdivided into three lithofacies, designated "Tpa, Tld, and Tpl." Tpa is chiefly limestone and was deposited in marshland and ponds. Tld consists chiefly of limestone and montmorillonite claystone that were deposited in varied environments, including ponds and flood plains. Tpl is almost entirely Mg clays, limestone, and dolomite, which were deposited in playas and associated marshland. The largest area of playa sediments, termed East Playa, is in the east-central part of the basin. Limestone and dolomite seepage mounds and caliche-breccia masses were formed along zones of ground-water leakage within East Playa.

Chemically precipitated Mg smectite and sepiolite form large deposits in Tpl. Sepiolite was formed in water of low salinity, whereas Mg smectite was formed in water of higher salinity. Authigenic celadonitic illite and K-feldspar are commonly associated with Mg smectite and are very likely reaction products of montmorillonite in saline, alkaline water. Silicic vitric ash layers were locally altered to phillipsite and K-feldspar in saline, alkaline water and to montmorillonite as a result of leaching by water of low salinity. Carbonate rocks are locally silicified along seepage zones.

Carbonate minerals of the Pliocene deposits have stable isotopic compositions that vary with their lithofacies. Tpa limestones deposited in or near areas of spring discharge have low $\delta^{18}O$ values averaging +16.6. Tld limestones recrystallized in the vadose zone have higher $\delta^{18}O$ values, averaging +18.1. Carbonate minerals of Tpl are the most $\delta^{18}O$-rich, with calcite averaging +20.3 and dolomite +24.3, reflecting evaporative concentration in playas. Much of the dolomite is of replacement origin yet is in approximate isotopic equilibrium with the calcite it replaces.

Relatively pure sepiolite has lower $\delta^{18}O$ values than do Mg smectite clays, which fits with the lower salinity inferred for sepiolite precipitation. Sepiolite and Mg smectite disseminated in limestone fall outside the oxygen isotopic limits of the relatively pure clays, possibly because of diagenetic recrystallization.

The Pliocene climate was wetter than that of the present, and springs were more widespread in the Amargosa basin. This dolomite may have formed in water isotopically and chemically about the same as that of the calcite, and dolomitization may have been chiefly a result of the differing crystallization kinetics of calcite and dolomite and of fluctuating water chemistry in a playa environment. The saline, alkaline water of East Playa resulted from evaporation of a mixture of alkali bicarbonate runoff from the volcanic terrane to the north with Ca-Mg bicarbonate water discharged in springs from the Ash Meadows ground-water system, whose recharge area is principally in Paleozoic carbonate rocks to the east and northeast. Seepage along fault zones in East Playa was initially of Ash Meadows type, low in silica, and changed to siliceous water, derived from volcanic rocks, resulting in silicification of carbonate deposits. Caliche breccias along the western margin of the basin record a similar change in the composition of groundwater seepage, which may be attributed to a period of decreased precipitation about 2.5 Ma which reduced recharge from nearby carbonate rocks relative to that from more distant volcanic rocks to the north and northwest.

INTRODUCTION

The Amargosa Desert of Nevada-California (Fig. 1) is an area of major spring discharge that contains large amounts of spring-related carbonate deposits and Mg clays. Research in this area has been confined largely to mineralogy of the Mg clays, which form the largest known deposits in the western United States. They were first described by Papke, who reported the occurrence of Mg smectite (1970) and sepiolite (1972) in the Amargosa Flat (Fig. 1). The mineralogy and chemistry of the clays was studied in detail by Khoury (1978), Khoury and others (1982), and Eberl and others (1982). They showed that much of the Mg smectite is stevensite, an essentially pure Mg silicate, with interlayered kerolite, a hydrous talc. Using the TEM, Teague (1981) further documented the Al-poor nature of some of the Mg clays, and he extended their known distribution outside the Amargosa Flat area, on which most of the earlier work had been done.

Previous work provides only limited information and varied interpretations about depositional environments of the basin-fill carbonates and clays. Fresh-water lakes and related environments were proposed by Walker and Eakin (1963) and Dudley and Larson (1976). Denny and Drewes (1965) postulated playas and wet meadows and considered the clays of Amargosa Flat to be playa deposits. Naff (1973) likewise accepted a playa environment for clays of Amargosa Flat.

A saline lake was proposed for precipitation of sepiolite by Papke (1972), but Khoury and others (1982) inferred nonsaline water from the isotopic data and suggested that "precipitation probably occurred during a pluvial period in shallow lakes or swamps" (1982, p. 327). Teague's work supported a playa interpretation, and he used the term "East Playa" to designate the large area in and around the Amargosa Flat that is underlain by Mg clays (Fig. 2).

Geological Society of America Bulletin, v. 97, p. 1488–1503, 7 figs., 2 tables, December 1986.