Evidence for an aeolian component of paleowetland deposits of the Las Vegas Formation

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Introduction

The Las Vegas Formation (LVF) is a middle Pleistocene to early Holocene sequence of fine-grained groundwater discharge deposits representing desert wetlands that occupied the Las Vegas Valley, NV between approximately 570 and 8.5 ka.

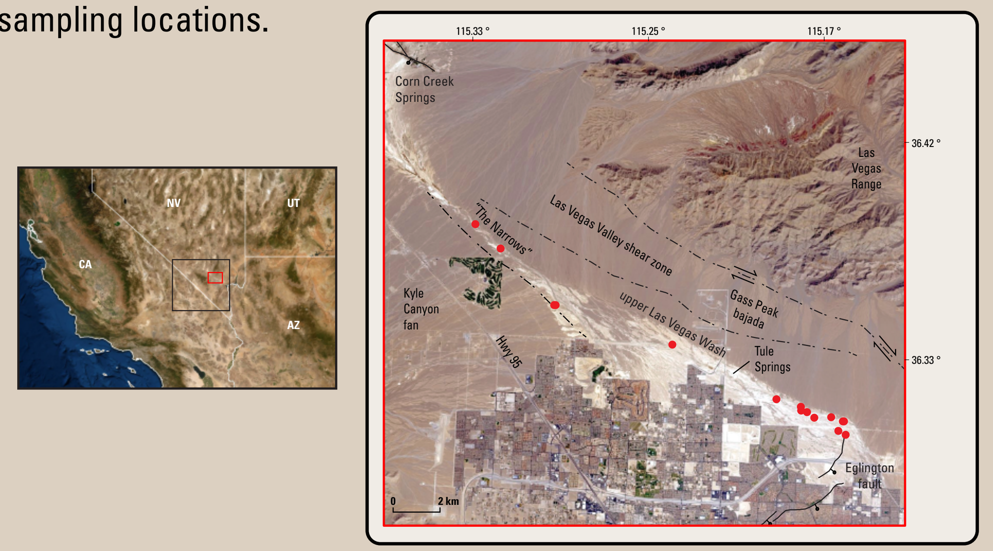
Desert wetlands are known to be sensitive to groundwater fluctuations, and studies of LVF deposits in Tule Springs Fossil Beds National Monument (TUSK) have demonstrated that wetland expansion and contraction occurred in direct response to abrupt climate oscillations in the recent geologic past.

Springer, K., B., Manker, C.R., and Pigati, J.S., 2015, Dynamic response of desert wetlands to abruptclimate change, Proceedings of the National Academy of Sciences of the United States of America, vol. 112, no.47, p. 14522-14526.

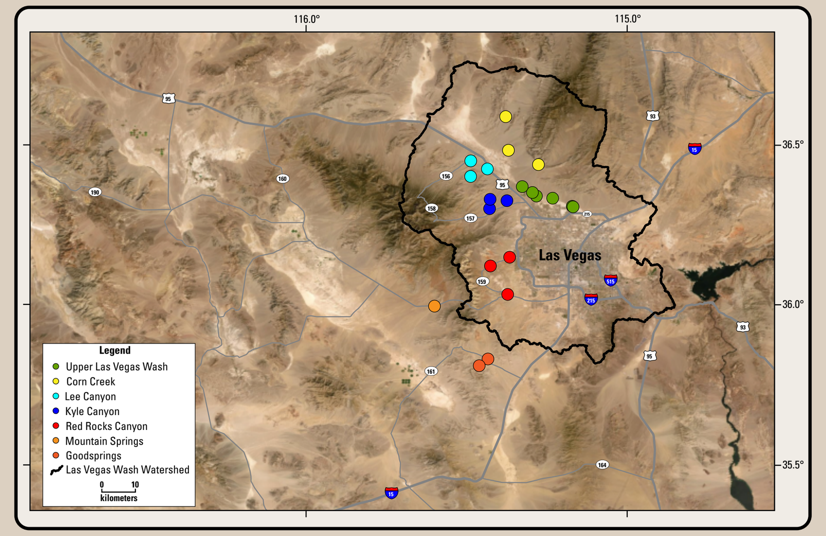
Here, we address one of the outstanding questions about the Las Vegas Formation which relates to the composition and sources of the clastic sediments that make up a large component of the deposits.

Location

The Las Vegas Formation study area centers around the Tule Springs Fossil Beds National Monument (TUSK) in the upper Las Vegas Wash, northern Las Vegas Valley, Nevada. Red circles mark sediment sampling locations.



Comparison sediments were collected from active washes mostly within the Las Vegas Wash (LVW) watershed. Bedrock within the LVW watershed is composed almost entirely (95%) of carbonate lithologies.



Hydrologic Setting

Las Vegas Formation sediments accumulated in various spring settings including outflow streams, spring pools, and marshes and wet meadows…

Modern | Sedimentary Record

Rheocrene discharge (outflow streams)

Limnocrene discharge (spring pools)

Helocrene discharge (wet meadows)

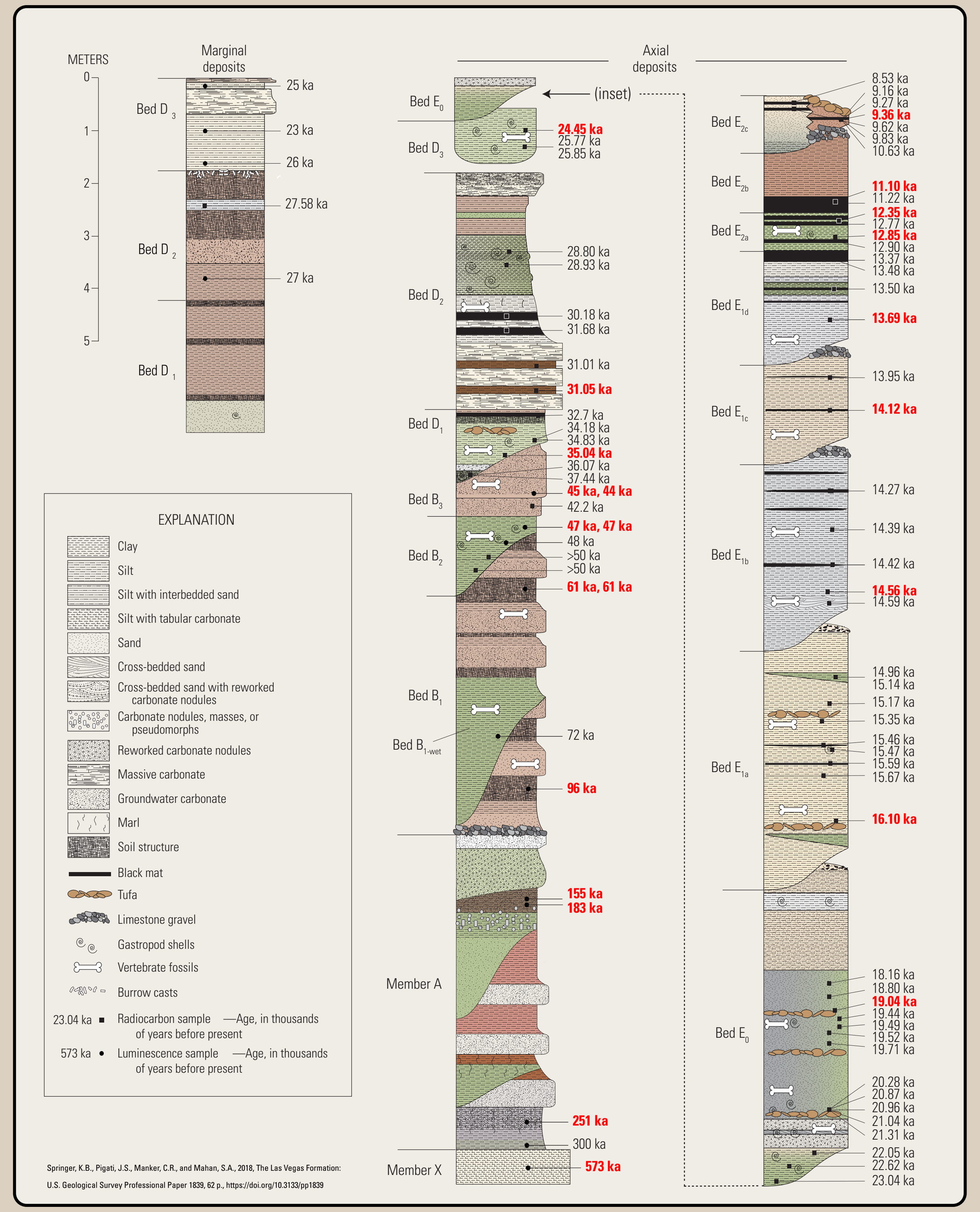
… but what depositional processes are responsible for sediment accumulation?

Purpose

In this study, we test the hypothesis of aeolian contributions to paleowetland deposits by evaluating properties of LVF sediments,and comparing them to properties of dominantly carbonate bedrock from the local watershed.

Stratigraphy

The LVF consists of 17 informal paleowetland units that represent distinct episodes of groundwater discharge separated by periods of surface stability (soils) and/or erosion. The formation also entombs many Pleistocene vertebrate fossils.



Springer, K.B., Pigati, J.S., Manker, C.R., and Mahan, S.A., 2018, The Las Vegas Formation: U.S. Geological Survey Professional Paper 1839, 62 p., https://doi.org/10.3133/pp1839

Unit	Hydrologic Setting	Age (ka)		
E_{2c}	Rheocrene	9.36	±	0.11
E_{2b}	Rheocrene	11.10	±	0.00
E_{2a}	Rheocrene	12.35	±	0.23
E_{2a}	Helocrene	12.85	±	0.12
E_{1d}	Rheocrene	13.69	±	0.14
E_{1c}	Rheocrene	14.12	±	0.21
E_{1b}	Rheocrene	14.56	±	0.38
E_{1a}	Rheocrene	16.10	±	0.21
E_0	Rheocrene	19.04	±	0.14
D_3	Helocrene	24.45	±	0.39
D_2	Helocrene	31.05	±	0.43
D_1	Limnocrene	35.04	±	0.50
B_3	Fluvial channels and overbank	44.00	±	6
B_3	Fluvial channels and overbank	45.00	±	7
B_2	Limnocrene	47.00	±	4
B_2	Limnocrene	47.00	±	4
B_1	Helocrene	61.00	±	10
B_1	Helocrene	96.00	±	5
A	Helocrene	155.00	±	12
A	Helocrene	183.00	±	15
A	Helocrene	251.00	±	18
X	Helocrene	573.00	±	52

Samples of LVF sediments collected for property determinations span the entire formation (noted in the startigraphic column above in red), and represent all hydrologic settings.

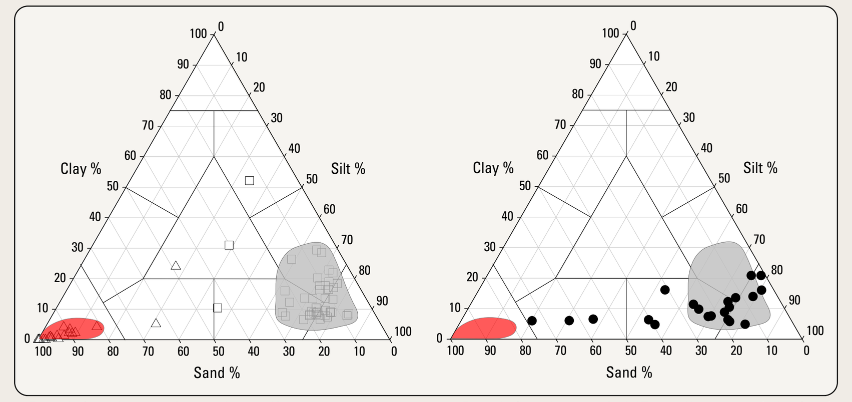
Results

Property determinations of Las Vegas Formation and local wash sediments

- **Particle Size** - Measured using laser diffraction methods
- **Mineralogy** - XRD and magnetic property measurements
- **Petrography** - Reflected and trasmitted light techniques
- **Chemistry** - WDXRF and ICP-OES and -MS

Particle Size

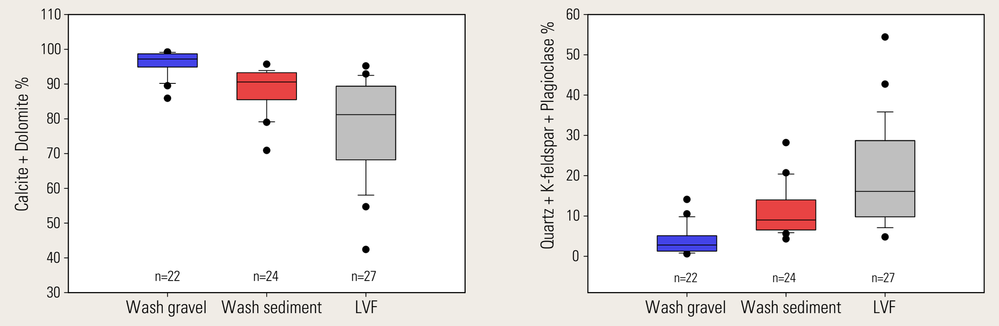
- Particle sizes of the LVF sediments range from silt to sandy-silt with an average median of about 35 micrometers.
- The sandy silt – silt texture of the LVF sediments are different from wash sediment and are consistent with modern dust.



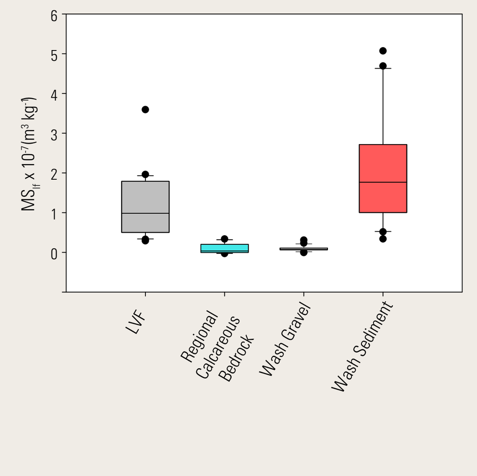
Particle sizes of wash sediments (triangles) are very different from local dust (squares).

Particle sizes of LVF sediments (circles), wash sediment (dark gray domain) and local dust trap dust (light gray domain).

Mineralogy

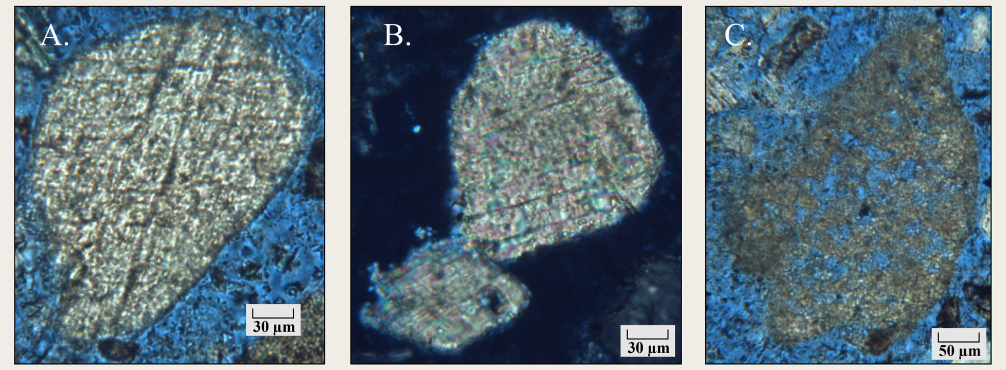


The mineralogy of LVF sediments is significantly different than wash sediment (p-Value = 0.002) and local bedrock (wash gravels; p-Value < 0.001). Local bedrock is high in calcite and dolomite content (mean = 97.2%; s.d. = 1.9%) and low in non-carbonate mineral content (mean = 2.7%; s.d. = 1.9%). Interestingly, the mineralogy of the wash sediment is significantly different than the wash gravel (calcareous minerals p-Value < 0.001; non-calcareous minerals p-Value < 0.001).

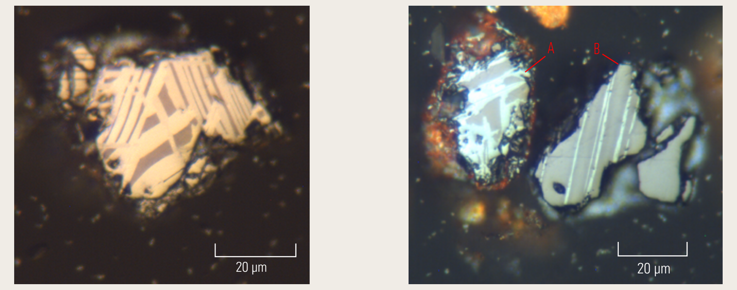


- Magnetic susceptibility (MS_{lf}) is a measure of magnetic-mineral content.
- LVF sediments contain higher concentrations of magnetic minerals than local and regional calcareous bedrock.
- The difference in MS_{lf} between the LVF sediment and the calcareous bedrock are statistically significant (p-Value <0.001).
- No statistically significant difference exists between Ms_{lf} of LVF sediments and wash sediments (p-Value = 0.133).
- Ms_{lf} of wash sediments are significantly different from the wash gravels (p-value < 0.001).

Petrography



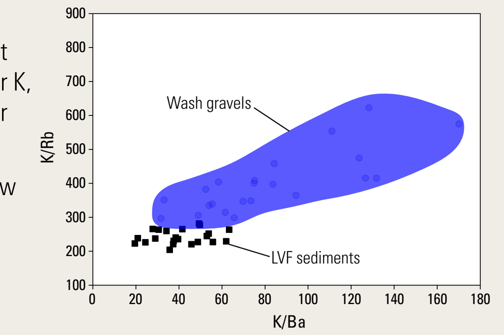
Photomicrographs showing typical very-fine to fine-sand sized carbonate minerals in LVF sediments. A. Sparry calcite approximately 240 µm in long dimension. B. Sparry calcite under crossed polarization exhibiting characteristic birefringence of calcite is approximately 150 µm in long dimension. C. Secondary carbonate formed as a precipitate in LVF sediments, approximately 450 µm in long dimension. Note areas of etching from acid treatment around the grain edges and in the center where blue epoxy is visible.

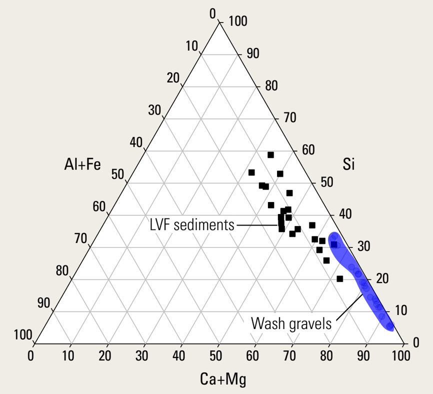


Photomicrographs of silt-sized magnetic minerals in LVF sediments. These minerals could only be formed in and derived from igneous rocks. Left panel shows a 40 µm titanomagnetite grain (magnetite with ilmenite lamellae) and the right panel shows (A) 35 µm magnetite (darker) with ilmenite and hematite (lighter), and (B) 40 µm illmenohematite where the ilmenite is darker, and the hematite are the lighter stripes.

Chemistry

- Potassium (K), rubidium (Rb), and barium (Ba) represent K-feldspar compositions where Rb and Ba subsitute for K, and their ratios provide a means to compare K-feldspar compositions among rock and sediment lithologies.
- K/Rb and K/Ba for LVF sediments have relatively narrow ranges and do not correspond to local bedrock (wash gravel)





- Ternary diagram representing composition of carbonate and non-carbonate minerals.
- LVF sediments have relatively high abundances of silica and aluminium+iron and are different than local bedrock (wash gravel) which contain high abundances of calcium+magnesium.

Conclusions

Comparisons of LVF sediment properties to those of local bedrock reveal differences that point to aeolian contributions from sediment sources outside of the local watershed.

Particle Size:

- Particle sizes of LVF sediments are consistent with:
  1) wind-derived sediments and classified as sandy- to clayey-loess.
  2) local dust deposited between 1984 - 2011 (no data during 2000- 2005).
- The silt component of these sediments represent aeolian contributions from mostly non-local sediment sources.
- The sand component in LVF sediments likely represents aeolian contributions from locally derived sediments.

Mineralogy:

- Through petrographic observations, LVF sediments contain sparry calcite in the very-fine to fine-sand size range.
- Abundances of carbonate, non-carbonate, and magnetic minerals present in LVF sediments are different than local bedrock.
- Magnetic mineral content in the LVF sediment is higher than local and regional carbonate bedrock.
- Magnetic minerals in LVF sediments are silt-sized and could only be derived from igneous rocks originally sourced outside the local watershed.

Chemistry:

- LVF sediments are chemically distinct from local bedrock.
- Compositions of K-feldspar differ between LVF sediments and local bedrock.
- Relative compositions of carbonate and non-carbonate minerals in LVF sediments are different than those of local bedrock.