Tephrochronology of faulted, fossil-bearing, Holocene to Pliocene sediments near Summer Lake, Oregon

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San Francisco, CA

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Home of the *undergraduate* electron microprobe

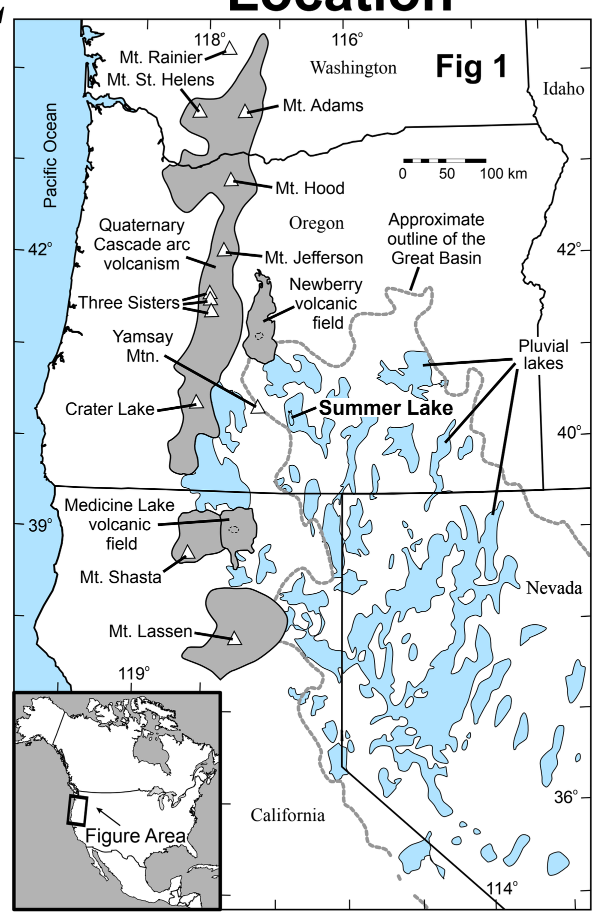
1 Abstract

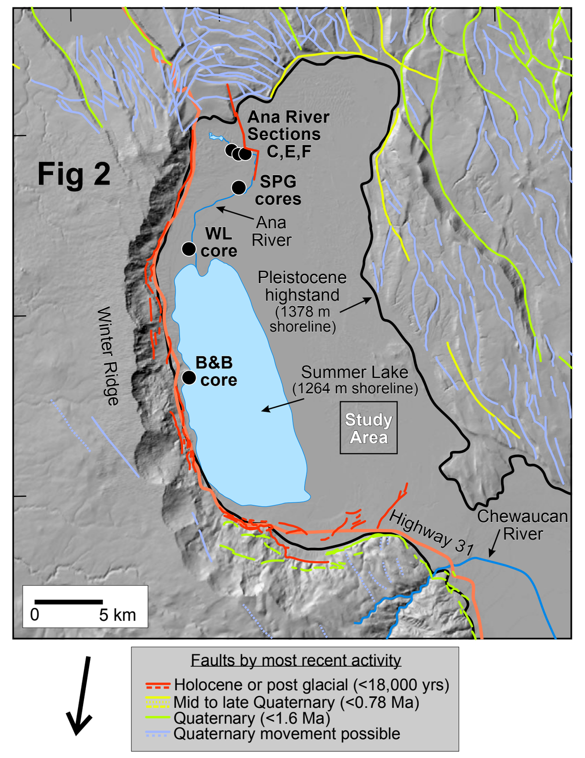
Lacustrine sediments preserved near Summer Lake, which occupies a portion of the northwestern sub-basin of Pluvial Lake Chewaucan contain an exceptional long-term record of Cascade arc pyroclastic volcanism and is therefore a key reference locality for tephrochronology. Multiple studies have also examined paleoclimate, paleomagnetic, and paleoseismic records. Nearly all of this work has been conducted on Pleistocene lacustrine sediments from outcrop and cores in the northwestern part of the Summer Lake basin. Here we document additional exposures of tephra-bearing sediments from two main locations and several minor exposures in southeastern portion of the basin, including much older sediments. The exposures are about 120 km east of the main locus of Cascade arc volcanism and about 40-50 km east of the line of rear arc volcanoes.

The southern location exposes about 8.5 m of sediment, mainly on the upthrown (east) side of a north-south trending fault which can be traced along the west side of the exposure. The uplifted block yielded 8 rhyolitic tephras and 4 mafic to intermediate tephras from 6 shallow trenches. The most prominent rhyolitic tephra is 30 cm thick and contains pumice up to 3 cm. The downthrown side yielded one rhyolitic tephra, identified as the ~25 ka Trego Hot Springs bed on the basis of major-element analysis of glass by electron microprobe at Concord University. Fish bones are abundant, and identification of one species (Ken Gobalet, written communication 2005) suggests a late Pliocene age for the uplifted sediments. In one exposure, the bounding fault juxtaposes Holocene dune sand against the uplifted sediments, and another shows evidence for at least two distinct earthquake events.

The second location, about 1.3 km NW of the first, exposes in a stream gully an additional north-south trending fault, about 6 m of sediment on the up thrown (east) side, and about 3 m of sediment on the down thrown side. At least six rhyolitic tephra beds are present ranging from 1 mm to 14 cm thick. Associated with a prominent 10 cm (8 cm reworked) white tephra bed on the down thrown block is a set of tephra-filled extensional fractures which parallel the fault.

2 Location





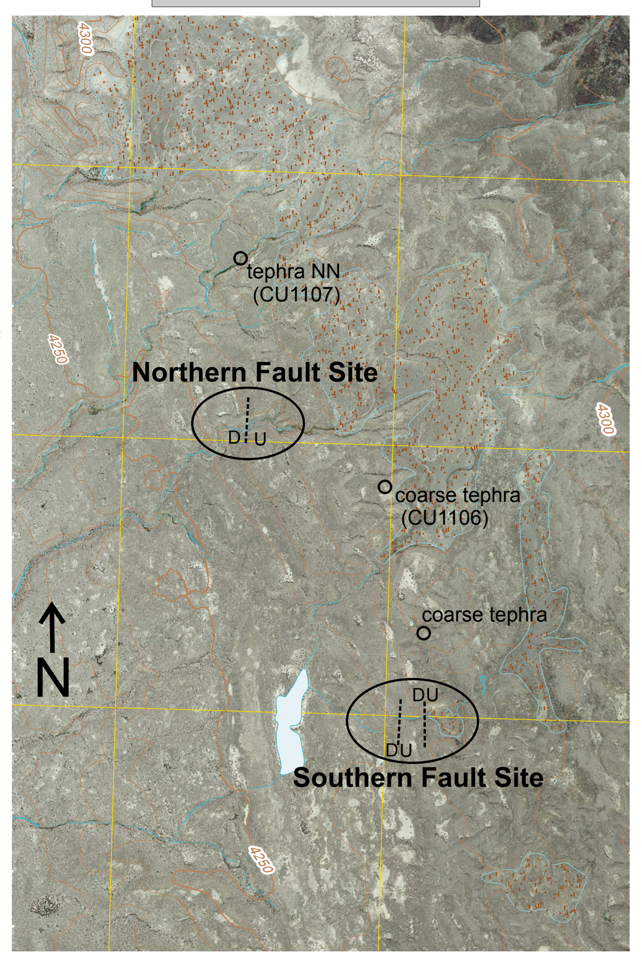
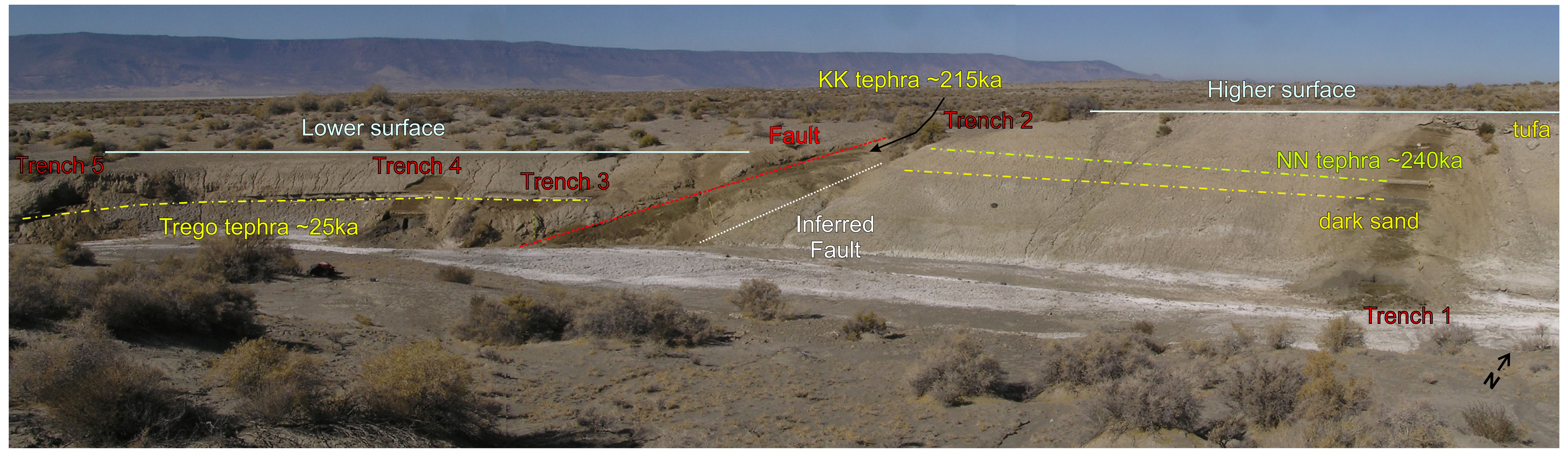


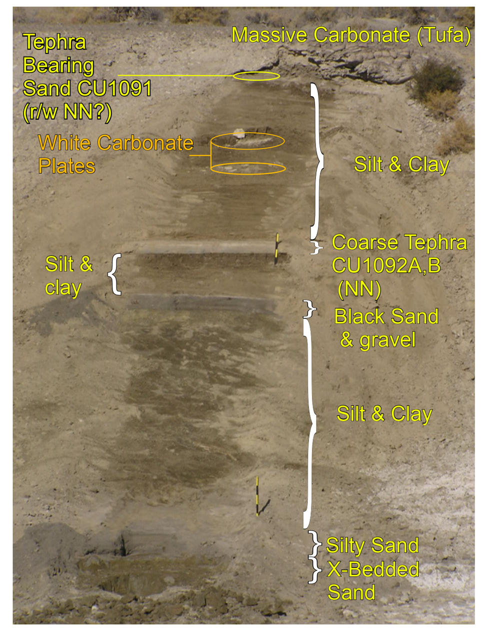
Fig 1. Regional map (above) modified from Kuehn & Negrini (2010). Summer Lake is located downwind from numerous tephra source volcanoes in the Cascade arc. More than 100 tephra beds are known in the Summer Lake basin. These provide excellent time-stratigraphic markers.

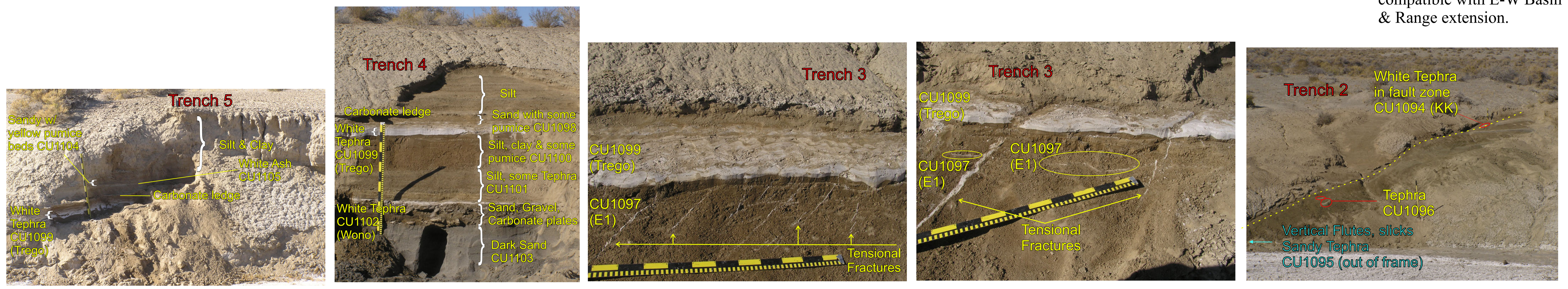
Fig 2. Summer Lake area map (upper right) modified from Kuehn & Negrini (2010) with faults added from Weldon et al. (2002) Note the large number of identified Basin and Range faults and the apparent relative absence of faults in the Pleistocene lake basin. Our excavations indicate that multiple faults do exist in the lake basin.

Fig 3. Site map (right) with base imagery from Google and with contours, hydrography, and 1 km UTM grid from USGS geoPDF quads Loco Lake and South of Ana River. Note the fault locations discussed in subsequent boxes. All faults show down-to-the-west displacment. Note also the potentially uplifted sediments in the upper left corner of the site map.

3 Northern Fault Site

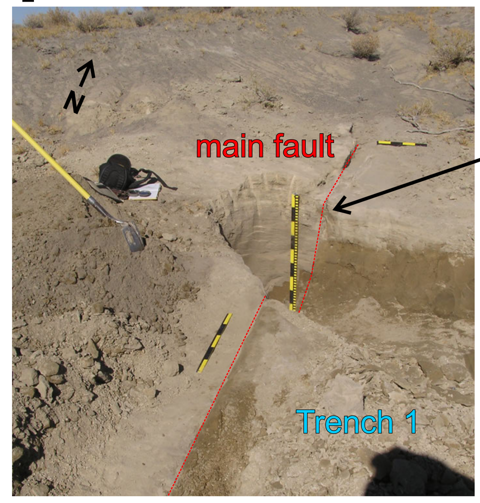




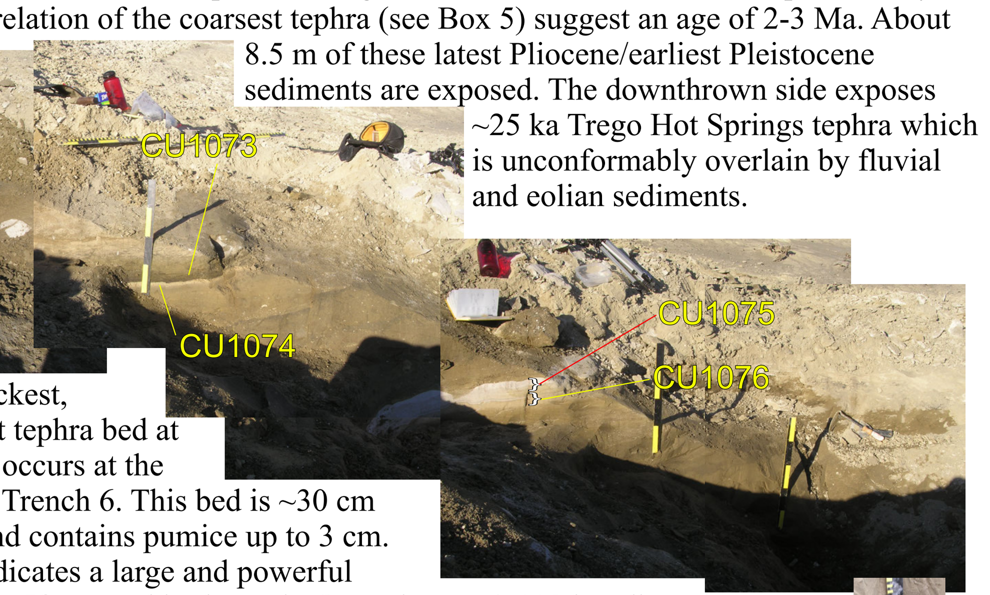


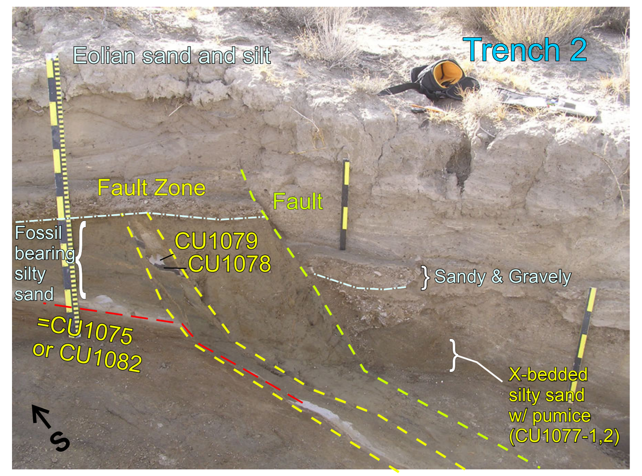
At the north fault site, displacement is observed in both the tephra sequence and the ground surface. The offset of the ground surface suggests several meters of postglacial displacement. The older NN tephra lies a few meters higher than the younger Trego tephra. At Ana River (Fig 2), the Trego and NN tephras are separated by about 15 m of section. This suggests 10-20 meters of displacement along the fault. Slickensides and flutes in the fault surface indicate primarily vertical movement. Tephra-filled fractures are compatible with E-W Basin & Range extension.

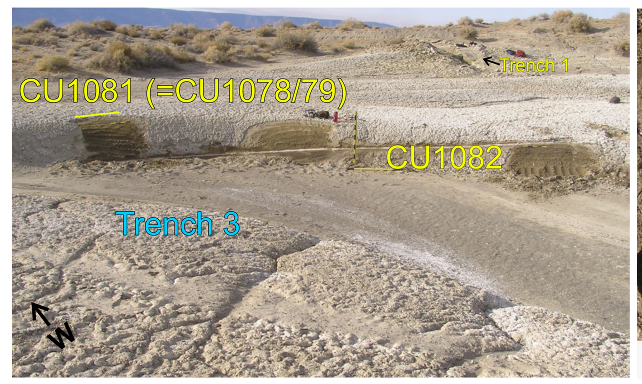
4 Southern Fault Site



At the southern fault site, the main fault displaces older lacustrine sediments and post-glacial (Holocene?) fluvial and eolian sediments. At trench 2, there is evidence for at least two (3?) episodes of displacement. On the upthrown (east) side are fossil and tephra-bearing sediments. The fish fossils and preliminary correlation of the coarsest tephra (see Box 5) suggest an age of 2-3 Ma. About 8.5 m of these latest Pliocene/earliest Pleistocene sediments are exposed. The downthrown side exposes ~25 ka Trego Hot Springs tephra which is unconformably overlain by fluvial and eolian sediments.

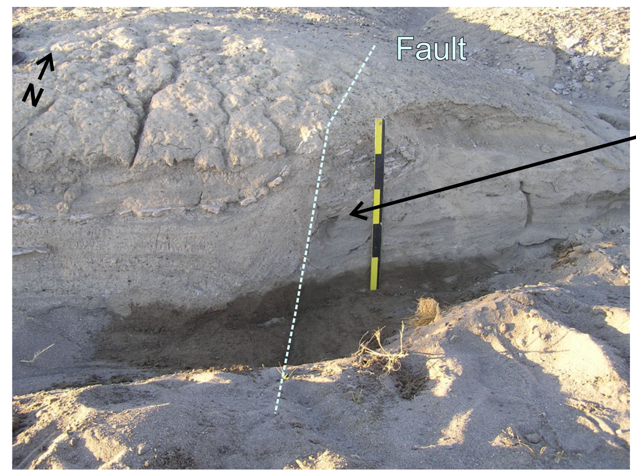


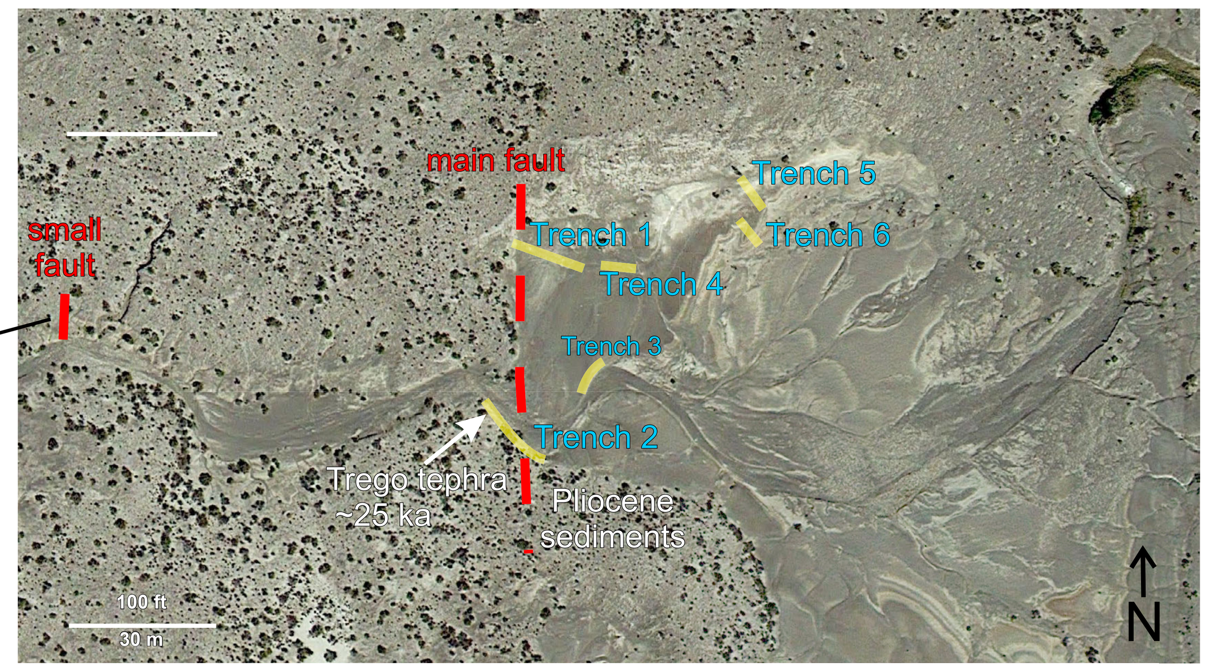


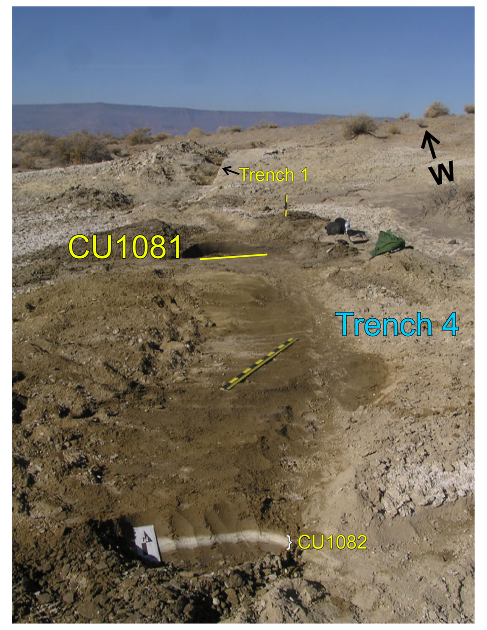


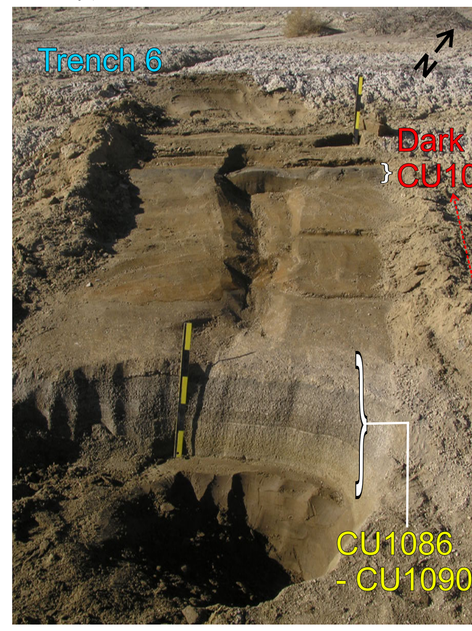
Fish and gastropod fossils from Trench 1

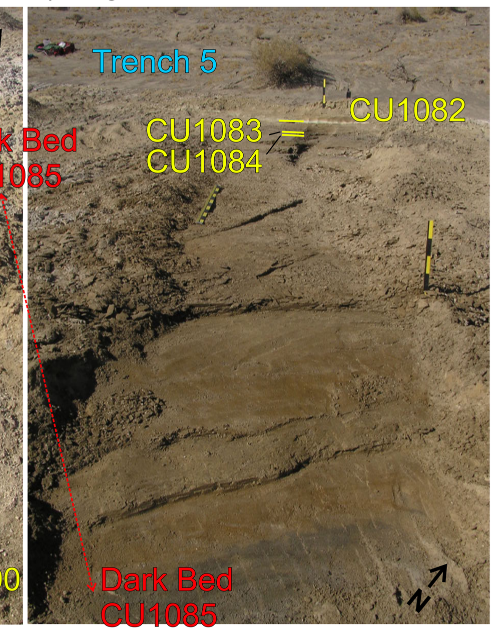
The thickest, coarsest tephra bed at the site occurs at the base of Trench 6. This bed is ~30 cm thick and contains pumice up to 3 cm. This indicates a large and powerful eruption. If sourced in the main Cascades arc (>110 km distant), it could be comparable to the climactic eruption of Mt. Mazama (Crater lake). If sourced in the rear arc (e.g. Yamsay mountain, ~40-50 km away), it would not need to be so very large.











5 Microprobe Data & Tephra Correlations

Selected microprobe data for samples from the study site (orange) and comparative samples (green). Analyses are from the ARL SEMQ micoprobe at Concord University except where indicated in the reference column. Some of the comparative data have lower Na2O and higher SiO2 due to alkali element migration during analysis. Note the two potential correlatives to the coarse bed at the southern fault site.

Sample		SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	Cl	Count	Ref.
CU1080	Average	**74.78**	**0.22**	**13.86**	**1.53**	**0.03**	**0.25**	**1.13**	**4.74**	**3.31**	**0.05**	**0.14**	**14**	
	StDev	0.58	0.03	0.41	0.16	0.02	0.02	0.08	0.28	0.08	0.07	0.02		
CU1099	Average	**75.14**	**0.24**	**13.61**	**1.55**	**0.03**	**0.21**	**1.09**	**4.78**	**3.24**	**0.03**	**0.13**	**16**	
	StDev	0.61	0.03	0.37	0.07	0.02	0.02	0.09	0.28	0.12	0.02	0.02		
Ana River bed 18 (Trego H.S. reference)		75.24	0.24	13.51	1.60		0.23	1.16	4.61	3.32		0.12	38	(1)
CU1097	Average	**77.02**	**0.15**	**12.82**	**1.15**	**0.01**	**0.13**	**0.81**	**4.33**	**3.48**	**0.02**	**0.11**	**11**	
	StDev	0.42	0.04	0.29	0.05	0.01	0.01	0.12	0.23	0.12	0.02	0.02		
Ana River bed E1		77.35	0.17	12.87	1.14		0.14	0.80	3.76	3.67		0.11	10	(1)
CU1102	Average	**73.88**	**0.31**	**14.33**	**1.99**	**0.02**	**0.32**	**1.31**	**4.63**	**3.08**	**0.04**	**0.11**	**13**	
	StDev	0.57	0.04	0.28	0.09	0.03	0.04	0.17	0.29	0.11	0.03	0.02		
Ana River bed F (Wono reference)		73.93	0.31	14.14	2.01	0.02	0.28	1.30	4.71	3.11		0.10		(3)
CU094	Average	**65.44**	**0.93**	**15.49**	**5.16**	**0.08**	**1.58**	**3.62**	**4.88**	**2.50**	**0.21**	**0.13**	**9**	
	StDev	1.30	0.07	0.34	0.54	0.03	0.31	0.58	0.34	0.23	0.04	0.02		
Ana River bed KK (Antelope Well tuff reference)		65.62	0.85	16.06	4.77		1.59	3.88	4.71	2.43		0.11	24	(1)
CU1092	Average	**69.94**	**0.63**	**14.51**	**3.56**	**0.11**	**0.68**	**2.30**	**5.32**	**2.71**	**0.14**	**0.10**	**13**	
	StDev	0.60	0.05	0.56	0.14	0.04	0.03	0.26	0.22	0.12	0.03	0.01		
Ana River bed NN		70.01	0.63	15.20	3.52		0.72	2.33	4.74	2.78		0.10	14	(1)
CU1086-CU1090	Average	**70.32**	**0.51**	**14.98**	**3.00**	**0.12**	**0.62**	**1.98**	**5.56**	**2.76**	**0.07**	**0.11**	**56**	
	StDev	0.63	0.05	0.54	0.27	0.05	0.06	0.21	0.41	0.17	0.04	0.02		
RN092000-4b	Average	**71.66**	**0.52**	**15.27**	**3.18**		**0.59**	**1.99**	**3.80**	**2.86**		**0.12**	**19**	(2)
(same bed as above)	StDev	0.33	0.02	0.12	0.09		0.04	0.07	0.32	0.10		0.02		
2.1 Ma tephra in Grande Ronde Basin, NE Oregon		71.05	0.60	15.39	3.23		0.61	1.90	4.40	2.70		0.15		(2)
~2.8 Ma tephra in Burmister core, Bonneville basin, Utah		72.24	0.49	15.27	3.19	0.10	0.60	1.92	3.20	2.98				(4)

Data sources: (1) S. Kuehn unpublished data, (2) F. Foit unpublished data, (3) Davis (1985), (4) Williams (1994)

6 Future Plans

We plan further field studies to better describe these faults, to locate additional faults, and to better document the tephra reference stratigraphy.

We plan Ar-Ar dating of selected tephras including coarsest tephra bed (CU1086-CU1090) found at the southern fault site.

Electron microprobe analysis of reference samples that may correlate with the coarsest bed and analysis of potential source beds from Yamsay Mtn. are planned for Spring 2014.

Acknowledgements & References

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