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**SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM VARIOUS SITES
IN THE GOODMAN POINT PROJECT, MONTEZUMA COUNTY,
SOUTHWEST COLORADO**

by

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Report Prepared for

Crow Canyon Archaeological Center
Colorado

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INTRODUCTION

The analysis here of 24 obsidian artifacts from a number of PII and PIII sites in the Goodman Point Community study, Montezuma County in southwest Colorado exhibits a mix of Jemez Mountains, New Mexico El Rechuelos, Valles Rhyolite (Cerro del Medio), and Cerro Toledo Rhyolite obsidian in proportions not similar found in earlier studies (see Arakawa et al. 2011, Shackley 2013; Tables 1 and 2, Figures 1-3 here). The possible implications of which are discussed below. Additionally, Government Mountain and RS Hill/Sitgreaves Peak obsidian was present, as well as the Black Rock source in Millard County, Utah (Tables 1 and 2).

LABORATORY SAMPLING, ANALYSIS AND INSTRUMENTATION

All archaeological samples are analyzed whole. The results presented here are quantitative in that they are derived from "filtered" intensity values ratioed to the appropriate x-ray continuum regions through a least squares fitting formula rather than plotting the proportions of the net intensities in a ternary system (McCarthy and Schamber 1981; Schamber 1977). Or more essentially, these data through the analysis of international rock standards, allow for inter-instrument comparison with a predictable degree of certainty (Hampel 1984; Shackley 2011).

All analyses for this study were conducted on a ThermoScientific *Quant'X* EDXRF spectrometer, located at the University of California, Berkeley. It is equipped with a thermoelectrically Peltier cooled solid-state Si(Li) X-ray detector, with a 50 kV, 50 W, ultra-high-flux end window bremsstrahlung, Rh target X-ray tube and a 76 μm (3 mil) beryllium (Be) window (air cooled), that runs on a power supply operating 4-50 kV/0.02-1.0 mA at 0.02 increments. The spectrometer is equipped with a 200 l min⁻¹ Edwards vacuum pump, allowing for the analysis of lower-atomic-weight elements between sodium (Na) and titanium (Ti). Data acquisition is accomplished with a pulse processor and an analogue-to-digital converter.

Elemental composition is identified with digital filter background removal, least squares empirical peak deconvolution, gross peak intensities and net peak intensities above background.

The analysis for mid Zb condition elements Ti-Nb, Pb, Th, the x-ray tube is operated at 30 kV, using a 0.05 mm (medium) Pd primary beam filter in an air path at 200 seconds livetime to generate x-ray intensity Ka-line data for elements titanium (Ti), manganese (Mn), iron (as Fe_2O_3^T), cobalt (Co), nickel (Ni), copper, (Cu), zinc, (Zn), gallium (Ga), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), niobium (Nb), lead (Pb), and thorium (Th). Not all these elements are reported since their values in many volcanic rocks are very low. Trace element intensities were converted to concentration estimates by employing a quadratic calibration line ratioed to the Compton scatter established for each element from the analysis of international rock standards certified by the National Institute of Standards and Technology (NIST), the US. Geological Survey (USGS), Canadian Centre for Mineral and Energy Technology, and the Centre de Recherches Pétrographiques et Géochimiques in France (Govindaraju 1994). Line fitting is linear (XML) for all elements but Fe where a derivative fitting is used to improve the fit for iron and thus for all the other elements. When barium (Ba) is analyzed in the High Zb condition, the Rh tube is operated at 50 kV and up to 1.0 mA, ratioed to the bremsstrahlung region (see Davis 2010; Shackley 2011). Further details concerning the petrological choice of these elements in Southwest obsidians is available in Shackley (1988, 1995, 2005; also Mahood and Stimac 1991; and Hughes and Smith 1993). Nineteen specific pressed powder standards are used for the best fit regression calibration for elements Ti-Nb, Pb, Th, and Ba, include G-2 (basalt), AGV-2 (andesite), GSP-2 (granodiorite), SY-2 (syenite), BHVO-2 (hawaiite), STM-1 (syenite), QLO-1 (quartz latite), RGM-1 (obsidian), W-2 (diabase), BIR-1 (basalt), SDC-1 (mica schist), TLM-1 (tonalite), SCO-1 (shale), NOD-A-1 and NOD-P-1 (manganese) all US Geological Survey standards, NIST-278 (obsidian), U.S. National Institute

of Standards and Technology, BE-N (basalt) from the Centre de Recherches Pétrographiques et Géochimiques in France, and JR-1 and JR-2 (obsidian) from the Geological Survey of Japan (Govindaraju 1994).

The data from the WinTrace software were translated directly into Excel for Windows software for manipulation and on into SPSS for Windows for statistical analyses. In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run. RGM-1 a USGS obsidian standard is analyzed during each sample run of 20 for obsidian artifacts to check machine calibration (Table 1).

Source assignments were made by reference to the laboratory data base (see Shackley 1995, 2005), and Nelson and Tingey (1997). Further information on the laboratory instrumentation can be found at: <http://www.swxrflab.net/>. Trace element data exhibited in Table 1 are reported in parts per million (ppm), a quantitative measure by weight (see also Figures 1 and 2).

DISCUSSION

The Jemez Sources of Archaeological Obsidian

Taken together, the pre-caldera and caldera sources of archaeological obsidian in the Jemez Mountains of northern New Mexico (approximately 250 km SW of these sites) are volumetrically the largest sources in the Southwest (Shackley 2005). El Rechuelos obsidian derived from a rhyolite dome complex along Cañada del Ojitos north of the Valles Caldera is a pre-caldera event dated to about 2.09 mya (Kempster et al. 2007). El Rechuelos obsidian erodes into the Chama River and then into the Rio Grande, probably not an issue for this procurement (Shackley 2005).

Cerro del Medio a resurgent dome from the Valles Rhyolite caldera collapse is dated to about 1.23 mya and is volumetrically the largest single archaeological obsidian source in the

Southwest (Gardner et al. 2007; Phillips 2004; Shackley 2005). This eruptive event was relatively quiet compared to the previous Cerro Toledo eruption that carried ash well to the southeast of the caldera and created the Bandelier Tuff and high quality obsidian. Unlike Cerro Toledo Rhyolite obsidian, Valles Rhyolite has not eroded outside the caldera in any quantity, and so had to be originally procured from Cerro del Medio proper (Shackley 2005, 2012).

Prehistoric Procurement

All the sources present in this assemblage are from relatively great linear distances: the Jemez Mountains sources are about 250 km southeast, the San Francisco Volcanic Field sources (Government Mountain and RS Hill/Sitgreaves) are about 370 km southwest, and the Black Rock, Utah source is over 400 km northeast.

With respect to media for tool production, El Rechuelos, Valles Rhyolite, and Cerro Toledo Rhyolite can be considered equal. While Valles Rhyolite is available in larger nodule sizes and quantities, much of it contains spherulites, while the El Rechuelos glass generally does not (Shackley 2005). All three sources have been used throughout prehistory from Clovis periods onward, and Valles Rhyolite has been recovered from archaeological contexts continent wide (Hamilton et al. 2013; Steffen and LeTourneau personal communication).

Recent obsidian provenance research in the greater Mesa Verde region by Fumi Arakawa and Scott Ortman has shown shifts in procurement from about A.D. 600 to A.D. 1280 (Arakawa et al. 2011). During Basketmaker periods the diversity of obsidian source procurement is quite diverse mirroring relatively high residential mobility and a lack of social boundary defense or physically defended boundaries. By A.D. 1060 most of the obsidian raw material was procured exclusively from the Jemez Mountains sources. During Basketmaker III-Pueblo I periods about 61% came from El Rechuelos, 37% from Valles Rhyolite, and the remainder (about 2%) from

Cerro Toledo (Arakawa et al. 2011: Fig. 7; Figure 3 here). The distribution of Jemez Mountains sources here deviates from the Arakawa et al. (2011) study, but this is a smaller sample.

Perhaps most interesting is the one projectile point tip produced from the Black Rock source in eastern Millard County, Utah. This could have been a finished point or arrow exchanged as a single item or within a group of items from the north. Other data sets from these sites may shed some light here. The San Francisco Volcanic Field obsidian is probably representative of other Western Anasazi indications in these sites if my memory serves.

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Table 1. Elemental concentrations and source assignments for the archaeological specimens and USGS RGM-1 obsidian standard. All measurements in parts per million (ppm).

PD#	Site - 5MT	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
6	16777	636	43	9512	17	6	44	17	48	29	18	Valles Rhy (Cerro del Medio), NM
74	16778	583	50	9809	21	1	63	18	85	36	25	Cerro Toledo Rhy, NM
51	16781	660	43	9609	16	6	41	16	48	28	17	Valles Rhy (Cerro del Medio), NM
16	16784	618	42	5541	15	4	23	63	39	25	18	El Rechuelos, NM
32	16789	521	39	9219	16	6	42	16	48	27	16	Valles Rhy (Cerro del Medio), NM
106	16789	296	97	1748	1	39	2	18	5	13	3	not obsidian
142	16789	687	48	1095	18	3	46	18	48	32	26	Valles Rhy (Cerro del Medio), NM
302	16789	669	43	1018	17	3	41	16	47	29	18	Valles Rhy (Cerro del Medio), NM
16	16803	547	50	8036	10	71	18	73	45	30	11	Government Mtn, AZ
32	16803	893	47	1140	17	5	43	17	50	29	21	Valles Rhy (Cerro del Medio), NM
59	16805	623	41	5452	14	6	21	70	40	26	15	El Rechuelos, NM
99	16805	737	44	1014	17	5	43	16	48	30	24	Valles Rhy (Cerro del Medio), NM
139	16808	712	55	9844	21	1	57	17	83	35	28	Cerro Toledo Rhy, NM
88	604	359	57	8690	10	76	22	76	44	32	8	Government Mtn, AZ
167	604	719	43	9937	16	5	45	17	51	29	24	Valles Rhy (Cerro del Medio), NM
349	604	610	45	5827	16	3	20	67	40	28	17	El Rechuelos, NM
508	604	633	44	9892	17	3	43	17	47	28	22	Valles Rhy (Cerro del Medio), NM
598	604	286	10	3341	0	18	15	11	7	27	4	not obsidian
623	604	598	54	8449	10	69	18	70	45	31	13	Government Mtn, AZ
693	604	596	43	5451	15	3	19	65	44	27	23	El Rechuelos, NM
713	604	295	94	2170	0	47	3	19	7	17	4	not obsidian
941	604	642	45	5987	16	6	23	68	41	27	23	El Rechuelos, NM
993	604	397	41	7500	28	8	63	10	30	35	31	Black Rock, UT
997	604	907	52	7176	17	7	22	68	40	31	25	El Rechuelos, NM
1000	604	412	46	1049	41	0	86	17	27	67	54	RS Hill/Sitgreaves Pk, AZ
1021	604	662	44	9920	16	3	42	16	47	28	17	Valles Rhy (Cerro del Medio), NM
1252	604	547	38	8678	16	6	41	16	51	26	23	Valles Rhy (Cerro del Medio), NM
RGM1-S4		153	30	1296	14	10	23	22	12	25	9	standard
RGM1-S4		153	29	1305	15	10	26	22	10	25	11	standard
		4	5	8	1	2		3				

Table 2. Crosstabulation of site by source.

			Source						Total
			Valles Rhy (Cerro del Medio), NM	El Rechuelos, NM	Cerro Toledo Rhy, NM	Government Mtn, AZ	RS Hill/Sitgreaves Pk, AZ	Black Rock, UT	
Site - 5MT	604	Count	4	4	0	2	1	1	12
		% within Site - 5MT	33.3%	33.3%	0.0%	16.7%	8.3%	8.3%	100.0%
		% within Source	36.4%	66.7%	0.0%	66.7%	100.0%	100.0%	50.0%
		% of Total	16.7%	16.7%	0.0%	8.3%	4.2%	4.2%	50.0%
	16777	Count	1	0	0	0	0	0	1
		% within Site - 5MT	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
		% within Source	9.1%	0.0%	0.0%	0.0%	0.0%	0.0%	4.2%
		% of Total	4.2%	0.0%	0.0%	0.0%	0.0%	0.0%	4.2%
	16778	Count	0	0	1	0	0	0	1
		% within Site - 5MT	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%
		% within Source	0.0%	0.0%	50.0%	0.0%	0.0%	0.0%	4.2%
		% of Total	0.0%	0.0%	4.2%	0.0%	0.0%	0.0%	4.2%
	16781	Count	1	0	0	0	0	0	1
		% within Site - 5MT	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
		% within Source	9.1%	0.0%	0.0%	0.0%	0.0%	0.0%	4.2%
		% of Total	4.2%	0.0%	0.0%	0.0%	0.0%	0.0%	4.2%
	16784	Count	0	1	0	0	0	0	1
		% within Site - 5MT	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%
		% within Source	0.0%	16.7%	0.0%	0.0%	0.0%	0.0%	4.2%
		% of Total	0.0%	4.2%	0.0%	0.0%	0.0%	0.0%	4.2%
	16789	Count	3	0	0	0	0	0	3
		% within Site - 5MT	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
		% within Source	27.3%	0.0%	0.0%	0.0%	0.0%	0.0%	12.5%
		% of Total	12.5%	0.0%	0.0%	0.0%	0.0%	0.0%	12.5%
	16803	Count	1	0	0	1	0	0	2
		% within Site - 5MT	50.0%	0.0%	0.0%	50.0%	0.0%	0.0%	100.0%
		% within Source	9.1%	0.0%	0.0%	33.3%	0.0%	0.0%	8.3%
		% of Total	4.2%	0.0%	0.0%	4.2%	0.0%	0.0%	8.3%
16805	Count	1	1	0	0	0	0	2	
	% within Site - 5MT	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
	% within Source	9.1%	16.7%	0.0%	0.0%	0.0%	0.0%	8.3%	
	% of Total	4.2%	4.2%	0.0%	0.0%	0.0%	0.0%	8.3%	
16808	Count	0	0	1	0	0	0	1	
	% within Site - 5MT	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%	
	% within Source	0.0%	0.0%	50.0%	0.0%	0.0%	0.0%	4.2%	
	% of Total	0.0%	0.0%	4.2%	0.0%	0.0%	0.0%	4.2%	
Total	Count	11	6	2	3	1	1	24	
	% within Site - 5MT	45.8%	25.0%	8.3%	12.5%	4.2%	4.2%	100.0%	
	% within Source	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	
	% of Total	45.8%	25.0%	8.3%	12.5%	4.2%	4.2%	100.0%	

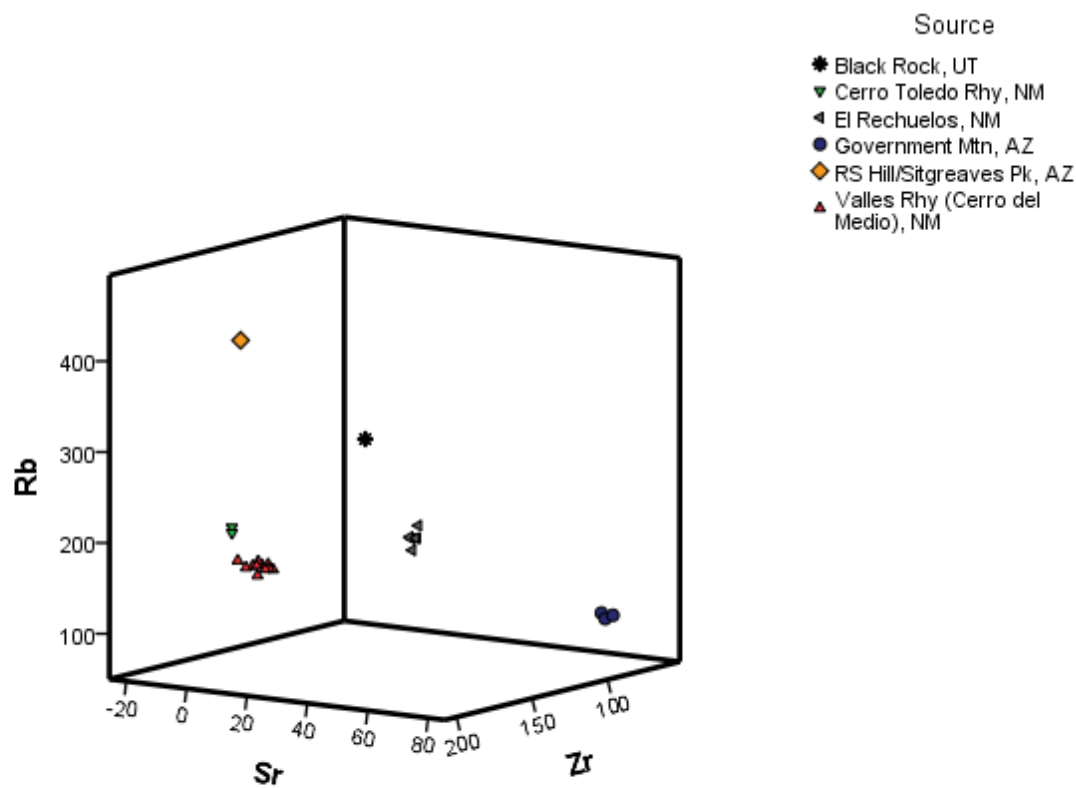


Figure 1. Sr, Rb, Zr three-dimensional plot of the elemental concentrations for all archaeological specimens. See Figure 2 below for Cerro Toledo and Valles Rhyolite discrimination.

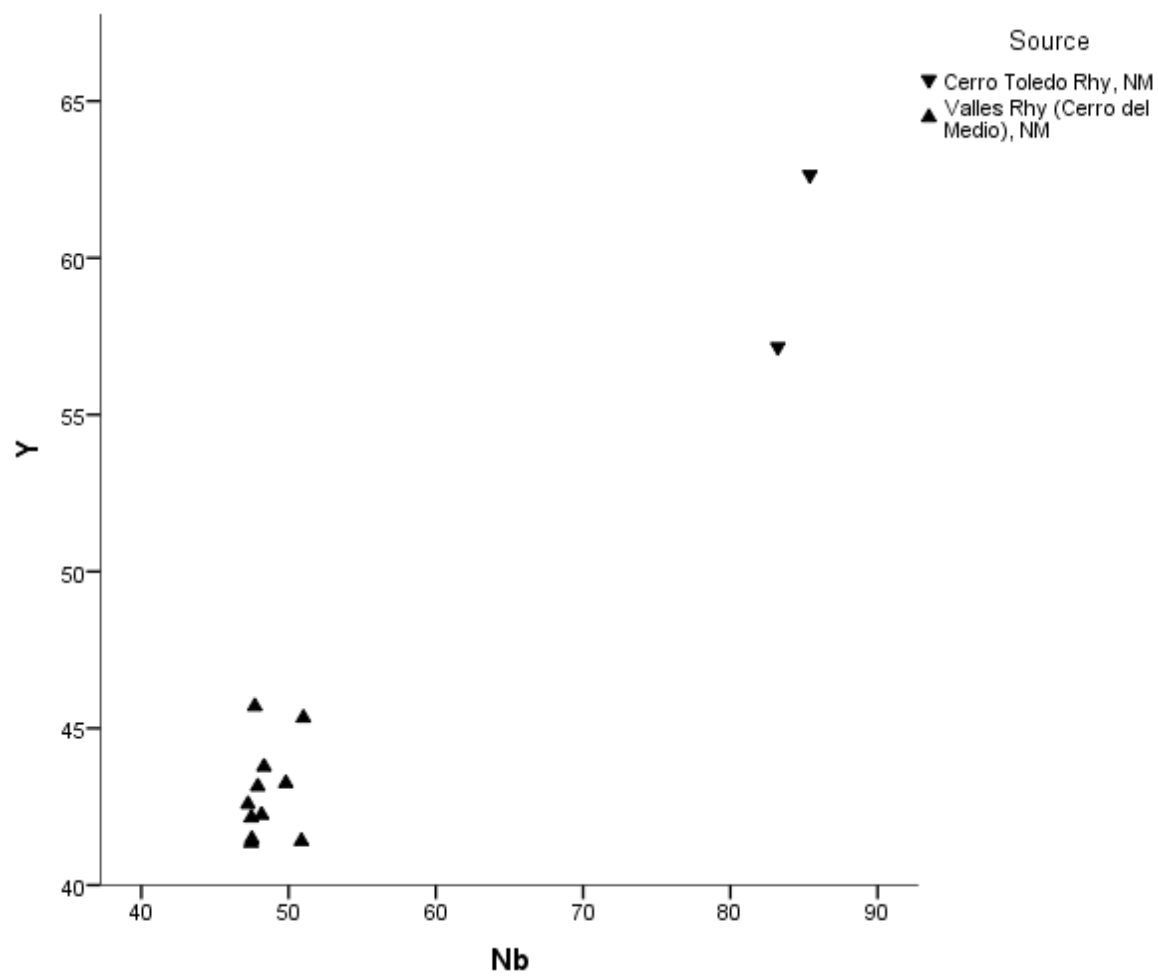


Figure 2. Nb versus Y bivariate plot of the Cerro Toledo and Valles Rhyolite samples providing discrimination.

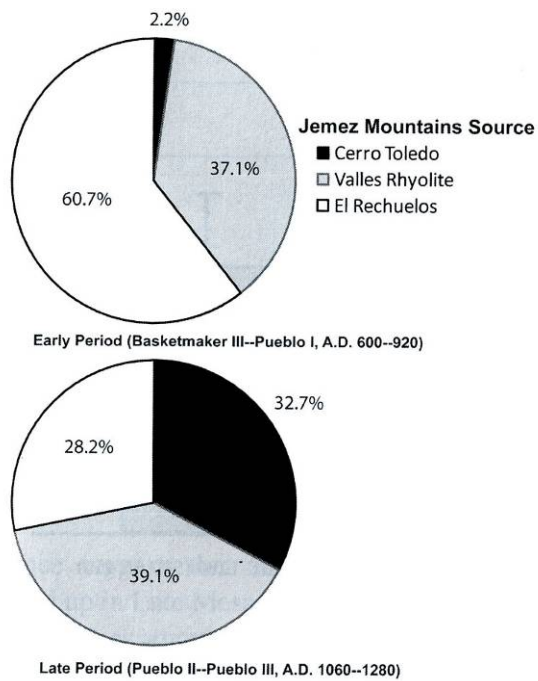


Figure 7. Jemez Mountains obsidian samples found in the central Mesa Verde region, by specific source.

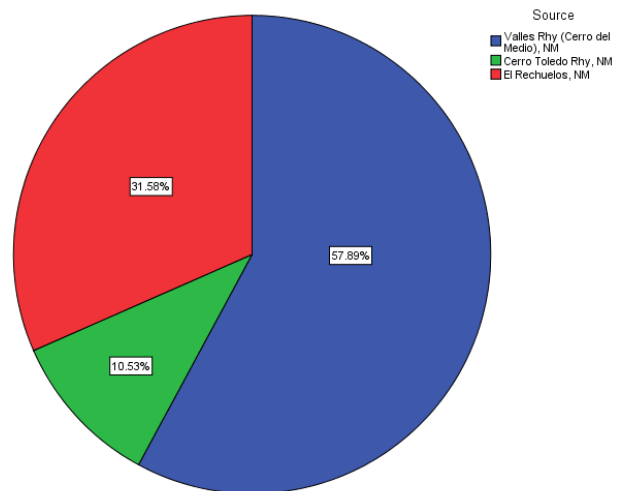


Figure 3. Left – proportional frequency distribution of obsidian source provenance through time in the Arakawa et al. (2011; Fig. 7) study; Right – proportional frequency distribution of obsidian source provenance in this study.