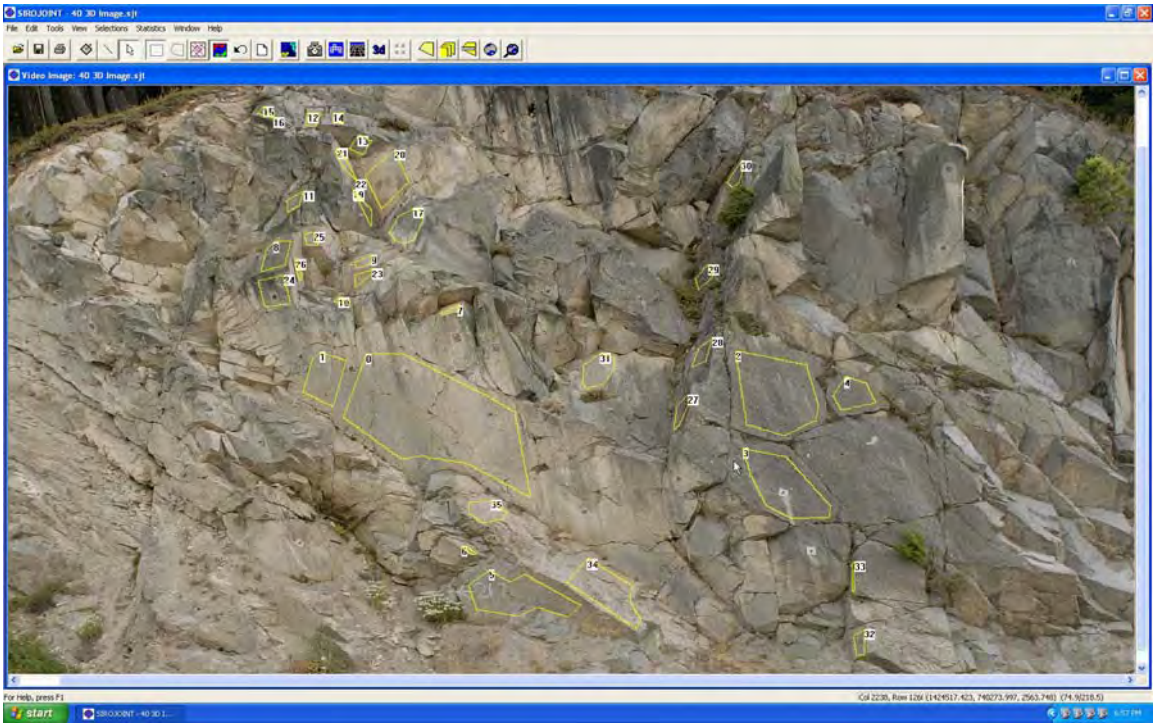
APPENDIX A
SIROVISION REPORTS

Digital Outcrop Modeling and Structural Mapping, I-90 Snoqualmie Pass East, Hyak to Keechelus Dam, Washington



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Prepared for

Wyllie & Norrish Rock Engineers and URS Corporation

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Purpose

3-D models of selected rock exposures along the westbound lane of I-90 in the vicinity of Slide Curve and Jenkins Knob were created using digital photogrammetry and used for structural mapping in support of rock slope design along those portions of the highway. This report contains a description of the fieldwork and data processing, screen capture images of each 3-D model for which structural mapping was performed, and appendices of supplementary data. Digital versions of the computer models and original photographs are included on accompanying DVDs.

Sirovision software was used to create the 3-Doutcrop models. The software consists of two applications: Siro3D for3-D model creation and SiroJoint for structural mapping and analysis. Additional information about the software is available at www.sirovision.com.

Fieldwork

Stereo pairs consisting of 10.2 megapixel digital photographs were taken on August 18 and 24, 2006. The photographs included coverage of road cuts adjacent to the interstate as well as an abandoned quarry about 100 feet northeast of the interstate, with locations selected under the direction of Dr. Robert Burk of Burk GeoConsult, LLC. Additional photographs of the quarry area immediately northeast of the interstate were obtained using a remotely operated camera attached to a 24-foot camera jib on September 13. The original photographs are included on the accompanying data DVDs.

Weather ranged from cloudy to sunny and temperatures ranged from about 50° to 70° during fieldwork. Most of the photographs were obtained across four lanes of traffic and a median barrier. In some instances, the orientation of the roadway required that photographs be taken into the sun and lens flare was a concern. In all but a few cases, however, lens flare was eliminated by holding a shade above the camera.

The photographs were obtained using a Nikon D200 digital SLR with a Nikkor AF-D 20 mm f2.8, AF-D 24 mm f2.8, or AF-D 50 mm f1.8 lens, all of which are supported by the Sirovision software used in this project, mounted on a standard camera tripod with a pan head. Beyond the use of a camera and lenses supported by the software, no special calibration was performed. A plumb bob used to mark each camera station and a retractable steel tape used to measure camera height at each station. A remote control was used to minimize the potential for camera movement. The files were saved as native Nikon NEF (also known as RAW) files to allow for greater processing flexibility and lossless conversion to the tiff format required by Sirovision.

Camera stations were marked on the shoulder or Jersey barrier of the eastbound lane of I-90 using spray paint and/or PK nails. Control points were marked and numbered on the rock face using spray paint. The letters “L” and “R” were used to denote the eastern and western points, respectively, in each pair of camera stations. The locations of both the camera stations and control points were later surveyed with RTK GPS and a

prismless total station by White Shield, Inc. and the coordinates provided in an Excel spreadsheet (Appendix A and data DVDs). The locations of the surveyed control points are superimposed on a USGS 1 m orthophoto in Figure 1.

The approximate distance between the camera stations and the outcrop, which is required to establish an appropriate baseline length, was estimated using a pocket laser distance finder to measure the length to the median barrier. That distance was doubled and 10 feet were added to establish the approximate distance to the outcrop, and the result divided by 6 to calculate the approximate required baseline length of 1/6 to 1/8 the distance between the outcrop and the camera locations.

Image Processing and3-D Model Creation

The photograph files were downloaded from the camera to a computer and converted from NEF to tiff format. Each photograph was then corrected to remove lens distortion using the default Sirovision parameters for the appropriate lens, and each pair was combined with the White Shield survey results to set up the 3-D orientation for each pair. This processes uses the camera station, camera height, and control point locations for each model and requires that the surveyed control point and three other common (but not surveyed) points be identified in each photograph. A 3-D model area was then defined for each pair, using as much of the overlap area as was practical in each case. Irregular topography, trees, and snow along the tops of the road cuts complicated this task and, as a consequence, some of the models are either truncated along their top edge or contain irregularities near the trees and snow. Finally, 3-D models were generated using block matching (the recommended Sirovision option for structurally or geometrically complicated outcrops). Each 3 by 3 block of pixels in the defined overlap area yielded one spatial data point on the outcrop face, which yielded models consisting of approximately 200,000 to 500,000 xyz points each. The models were saved as Sirovision rectified tiff files containing 3-D information. Other file formats, including ascii xyz or dxf files of the underlying 3-D meshes, were not exported but are available upon request.

Highly oblique photographs of rocks exposed in the quarry and far above the highway proved unsuitable for the photogrammetric calculations, even when a 24-foot camera jib was used to raise the camera and reduce the obliquity. Therefore, 3-D models of those outcrops could not be created.

Digital copies of all of the 3-D models are included as specially formatted Siro3D tiff files on the data DVDs accompanying this report.

Warning: Although the 3-D tiff files included on the data DVDs can be opened and viewed by many computer programs, saving them under the same file name will likely cause the 3-D information to be removed from the file. Sirovision3-D tiff files can be viewed, rotated, and zoomed using a free viewer available from www.sirovision.com (use the Import command for Siro3D tiff files).

Figure 1. Control point layout for Slide Curve outcrop models.

Structural Mapping

Structural mapping was performed at the Burk GeoConsult facility on October 30 with Norman Norrish and Robert Burk. A laptop computer running the SiroJoint component of Sirovision was connected to a 23 inch high resolution computer monitor, which allowed for collaborative mapping of significant structures by the project team. Figure 2 shows a typical SiroJoint model with a number of joint surfaces mapped.

SiroJoint structural models were made for the following 28 3-D models: 1 through 4, 10 through 13, and 22 through 41. Each model includes joint and fault surfaces identified during collaborative mapping, the orientations of which were exported and delivered electronically in spreadsheet format to Wyllie & Norrish and Burk GeoConsult for further plotting, analysis, and incorporation into slope designs. In addition to dip angles and dip directions, SiroJoint calculates the coordinates of the center, area, maximum chord length, the coordinates of the top and bottom edges for joints mapped as polygons. The coordinates of each point defining 3-D traces to which planes were fitted were also exported.

Both the SiroJoint3-D models showing the mapped joints and Excel spreadsheets containing the exported structural data are included on the data DVDs accompanying this report. SiroJoint models can be viewed using the Open command in the free Sirovision viewer.

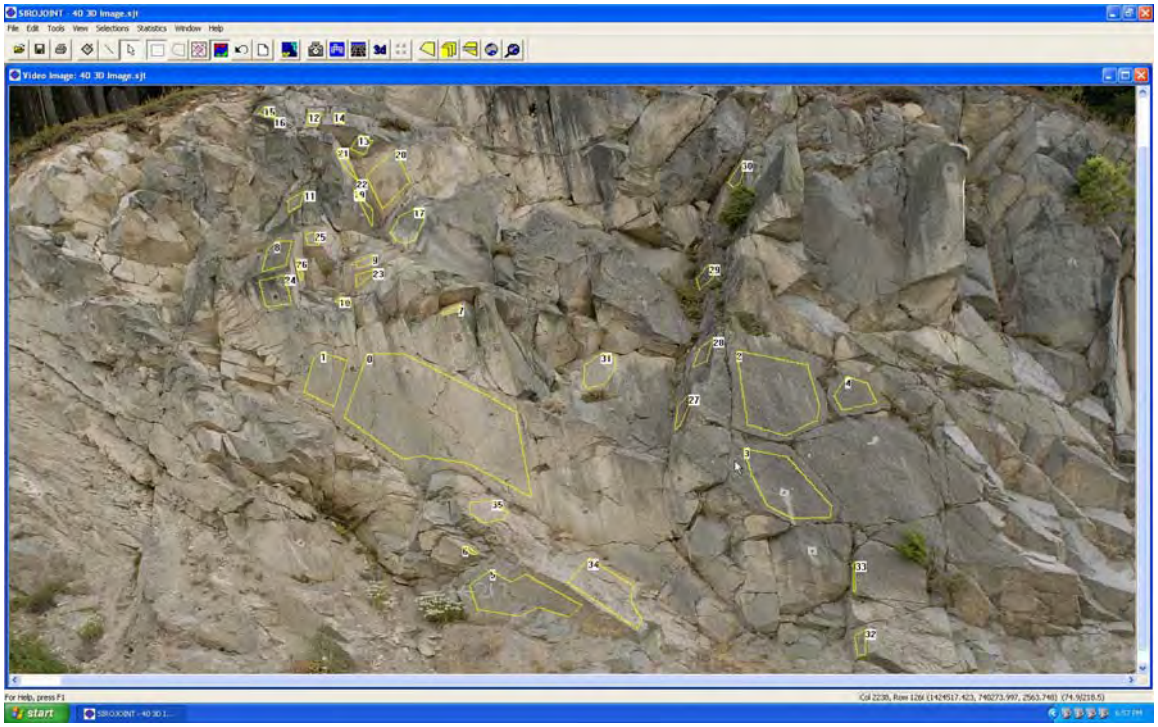

Figure 2. Example of a 3-D of outcrop 40, showing mapped joint planes as numbered yellow polygons. The polygon ID numbers in the image correspond to those listed in the 40_planes.xls file in Appendix B and on the data DVDs.

Appendix A: Surveyed Camera and Control Point Locations

Coordinates in Washington State Plane South Zone (feet), NAD83/91, NAVD88

1100	733552.49	1426672.69	2540.99	SIROVISION 01C
1101	733489.17	1426583.73	2542.43	SIROVISION 01L
1102	733465.07	1426612.19	2542.27	SIROVISION 01R
1103	733605.75	1426611.47	2540.04	SIROVISION 02C
1104	733539.37	1426528.97	2542.24	SIROVISION 02L
1105	733514.29	1426556.04	2542.71	SIROVISION 02R
1106	733681.26	1426555.84	2544.46	SIROVISION 03C
1107	733609.41	1426460.16	2541.77	SIROVISION 03L
1108	733582.79	1426485.75	2541.94	SIROVISION 03R
1109	733737.17	1426508.21	2542.89	SIROVISION 04C
1110	733676.32	1426403.24	2541.38	SIROVISION 04L
1111	733648.65	1426425.99	2541.49	SIROVISION 04R
1112	733803.52	1426463.68	2541.53	SIROVISION 05C
1113	733750.68	1426346.19	2541.35	SIROVISION 05L
1114	733721.71	1426366.90	2541.20	SIROVISION 05R
1115	733902.93	1426571.15	2685.09	SIROVISION 06C
1116	733802.50	1426310.53	2541.24	SIROVISION 06L
1117	733777.60	1426326.40	2541.22	SIROVISION 06R
1118	734200.76	1426452.04	2675.92	SIROVISION 07C
1119	734082.94	1426165.80	2540.20	SIROVISION 07L
1120	734036.01	1426184.45	2540.65	SIROVISION 07R
1121	734277.04	1426365.28	2633.49	SIROVISION 08C
1122	734188.65	1426127.78	2540.16	SIROVISION 08L
1123	734138.80	1426144.70	2540.35	SIROVISION 08R
1124	734318.16	1426479.75	2731.20	SIROVISION 09C
1125	734573.08	1426058.02	2537.22	SIROVISION 09L
1126	734478.45	1426066.04	2538.16	SIROVISION 09R
1127	734901.90	1426241.31	2563.16	SIROVISION 10C
1128	734959.98	1426086.27	2534.42	SIROVISION 10L
1129	734934.21	1426082.21	2534.57	SIROVISION 10R
1130	735021.92	1426261.29	2566.07	SIROVISION 11C
1131	735047.11	1426101.43	2533.37	SIROVISION 11L
1132	735023.15	1426097.37	2533.66	SIROVISION 11R
1133	735142.46	1426261.05	2546.56	SIROVISION 12C
1134	735171.93	1426123.25	2532.04	SIROVISION 12L
1135	735146.76	1426118.92	2532.28	SIROVISION 12R
1136	735254.82	1426289.68	2555.17	SIROVISION 13C
1137	735296.05	1426144.83	2530.53	SIROVISION 13L
1138	735271.03	1426140.51	2530.98	SIROVISION 13R
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1144	733567.94	1426910.59	2560.44	SIROVISION 15R
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1146	733574.48	1426856.55	2557.00	SIROVISION 16L
1147	733571.47	1426872.81	2560.56	SIROVISION 16R
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1154	742191.20	1424087.81	2536.78	SIROVISION 19L
1155	742169.20	1424086.29	2538.88	SIROVISION 19R
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1157	742140.57	1424082.84	2537.54	SIROVISION 20L
1158	742118.75	1424080.75	2537.17	SIROVISION 20R
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1162	742014.25	1424210.63	2551.92	SIROVISION 22C
1163	742039.42	1424073.75	2538.76	SIROVISION 22L
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1167	741614.55	1424031.52	2543.53	SIROVISION 23R
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1169	741554.26	1424024.88	2544.26	SIROVISION 24L
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1171	741452.66	1424112.83	2547.17	SIROVISION 25C
1172	741462.65	1424016.91	2545.13	SIROVISION 25L
1173	741446.28	1424016.13	2545.24	SIROVISION 25R
1174	741364.69	1424106.98	2546.19	SIROVISION 26C
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1176	741352.74	1424010.82	2546.21	SIROVISION 26R
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1183	741110.78	1424126.20	2551.24	SIROVISION 29C
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1185	741090.22	1424017.71	2547.40	SIROVISION 29R
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1188	741006.13	1424029.78	2548.25	SIROVISION 30R
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1224	735384.21	1426162.97	2533.14	SIROVISION 42R
1225	735486.03	1426309.26	2540.38	SIROVISION 43C
1226	735500.69	1426183.37	2533.62	SIROVISION 43L
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1242	735970.52	1426263.77	2535.58	SIROVISION 48R
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1244	736071.88	1426277.76	2535.89	SIROVISION 49L
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1248	736133.06	1426284.45	2535.50	SIROVISION 50R
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1251	736205.30	1426289.88	2535.10	SIROVISION 51R
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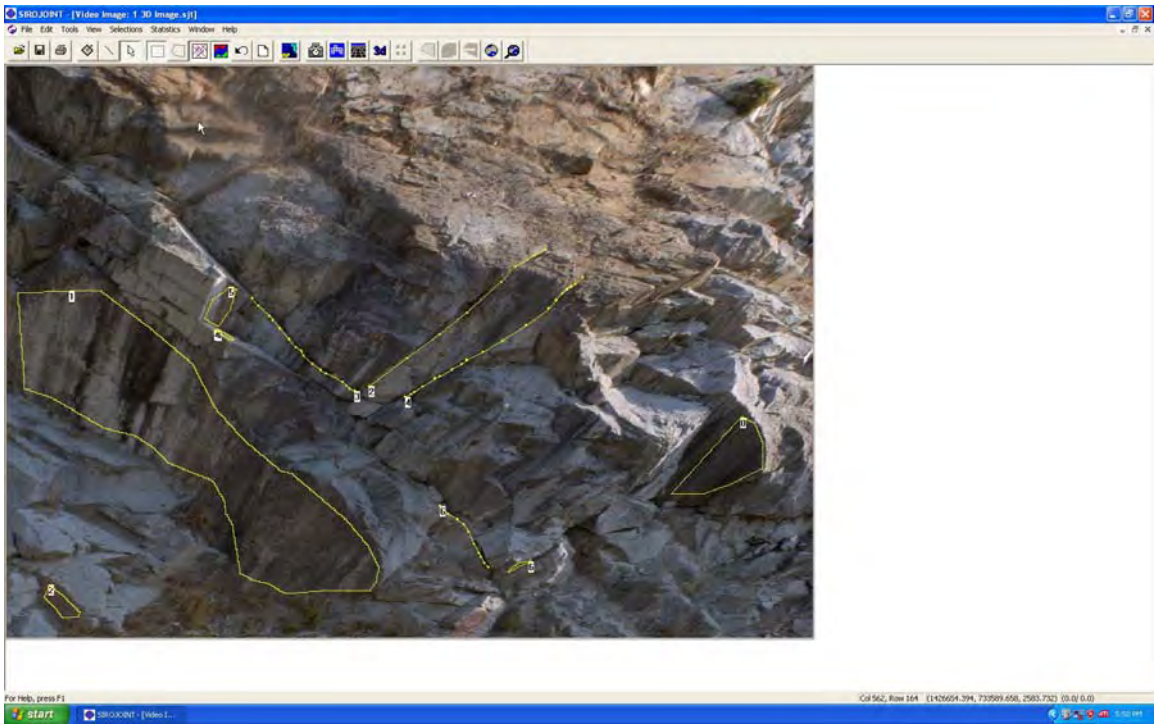
2379	733643.51	1426923.99	2611.80	D2
2367	733640.64	1426906.29	2617.40	D3
2378	733661.79	1426937.04	2628.89	D4
2369	733677.59	1426950.64	2641.59	D5
2370	733688.96	1426949.58	2651.72	D6
2377	733684.38	1426921.12	2652.37	D7
2371	733632.29	1426959.52	2603.47	D8
2372	733633.26	1426977.75	2603.87	D9
2373	733622.04	1426990.84	2597.71	D10
2374	733609.75	1426984.97	2585.16	D11
2375	733611.36	1427004.46	2592.24	D12
2376	733599.77	1427006.54	2585.38	D13
2366	733633.96	1426889.44	2594.95	D14

2345	733663.90	1426880.43	2605.80	D15
2365	733676.80	1426863.09	2611.05	D16
2343	733659.39	1426833.18	2597.02	D17
2342	733655.82	1426818.44	2592.81	D18
2340	733645.10	1426800.94	2583.59	D19
2339	733642.11	1426820.69	2580.60	20
2338	733631.71	1426799.55	2570.58	21
2336	733621.52	1426768.31	2569.78	22
2337	733627.13	1426779.86	2570.32	23
2335	733615.39	1426757.23	2566.86	24
2334	733612.22	1426762.77	2562.23	25
2341	733660.70	1426808.33	2601.73	27
2381	733627.16	1426766.17	2584.03	28

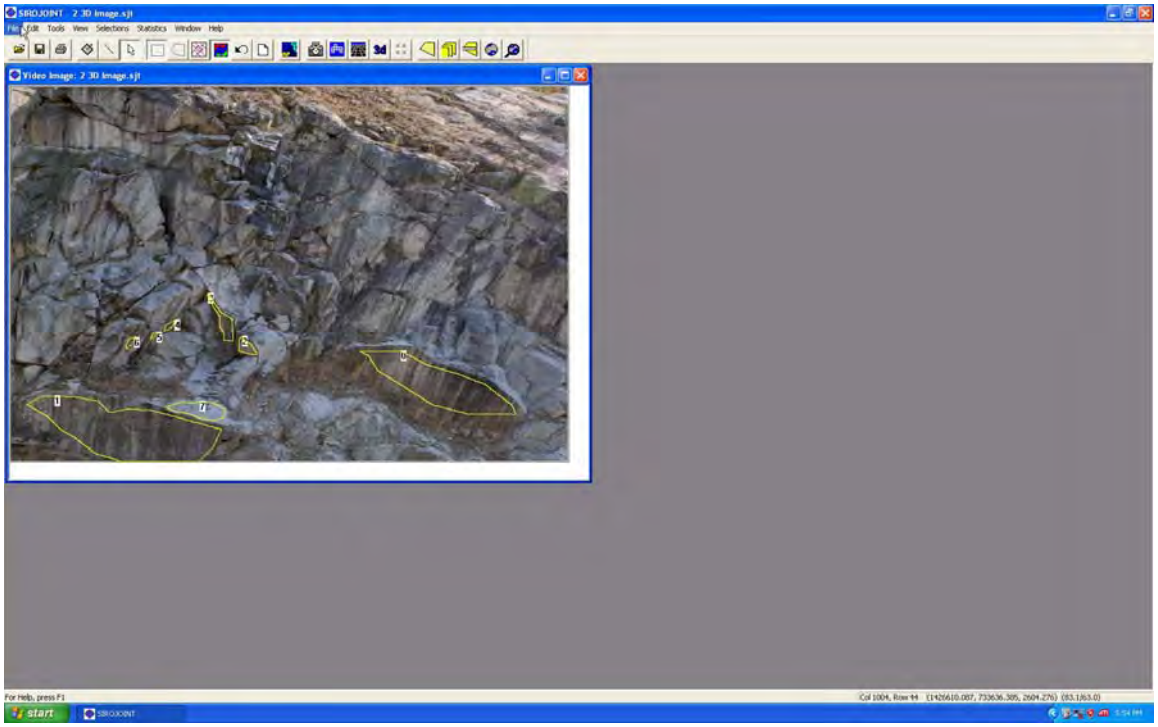
Appendix B: SiroJoint Screenshots

Model numbers below each screenshot refer to the control points shown in Figure 1.

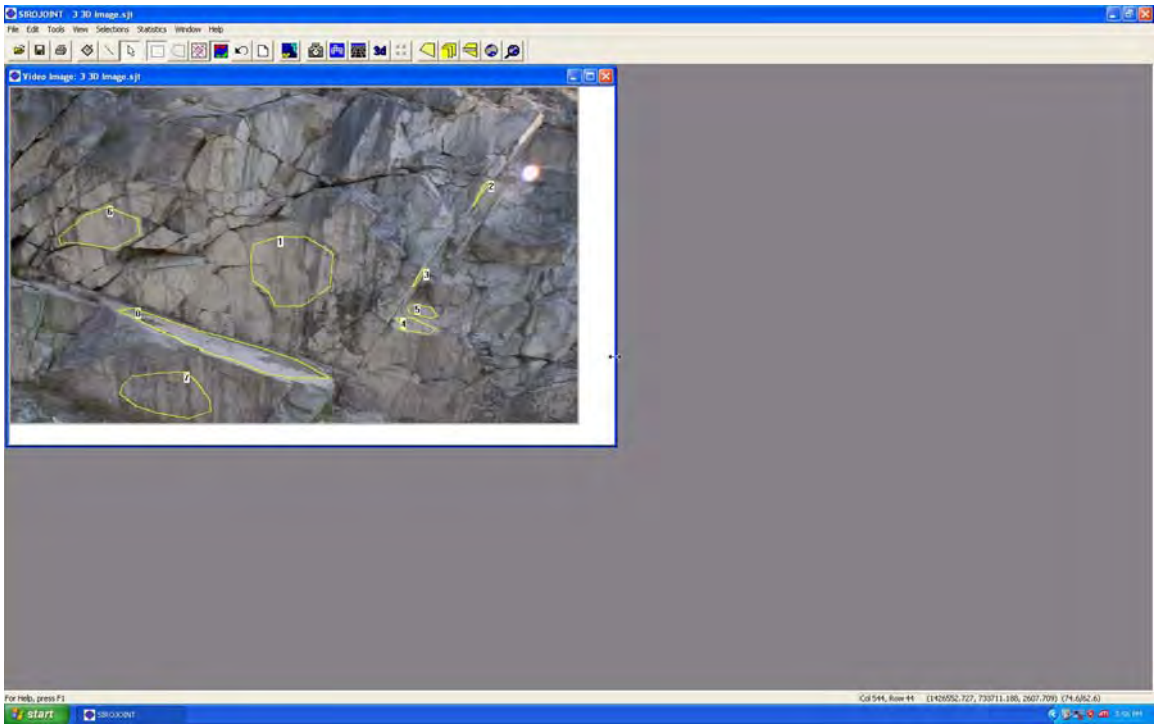
Joint ID numbers shown in the screenshots are keyed to orientations in the accompanying spreadsheet files.



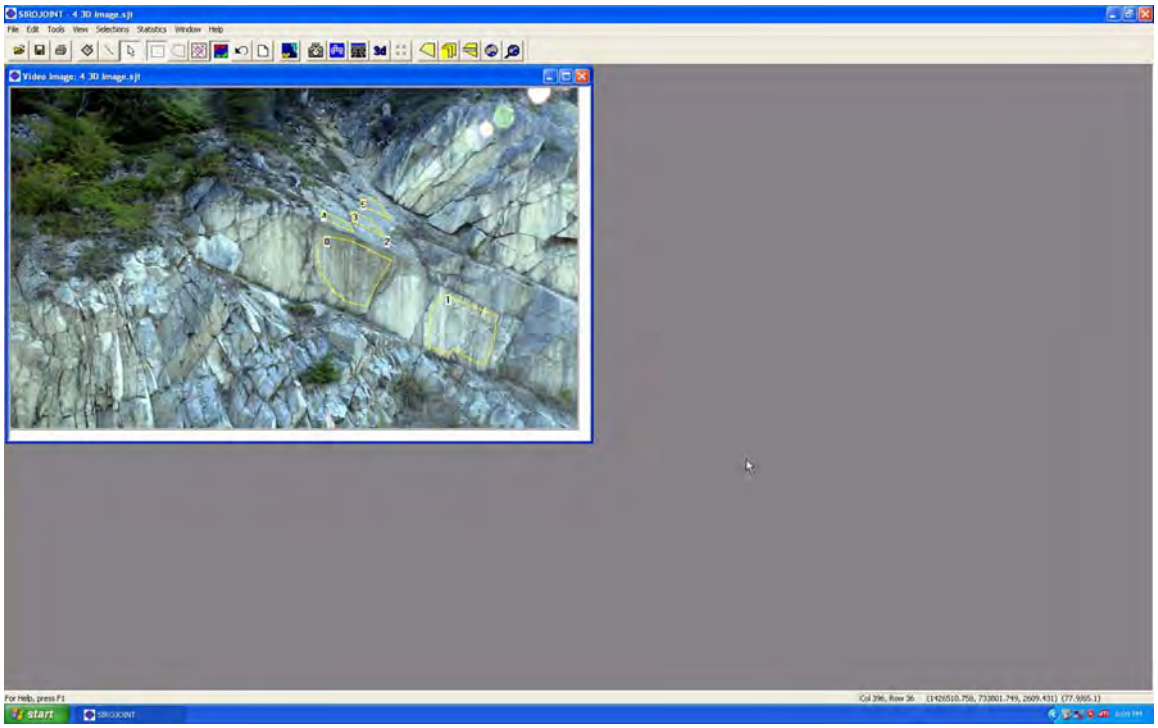
Outcrop model 1



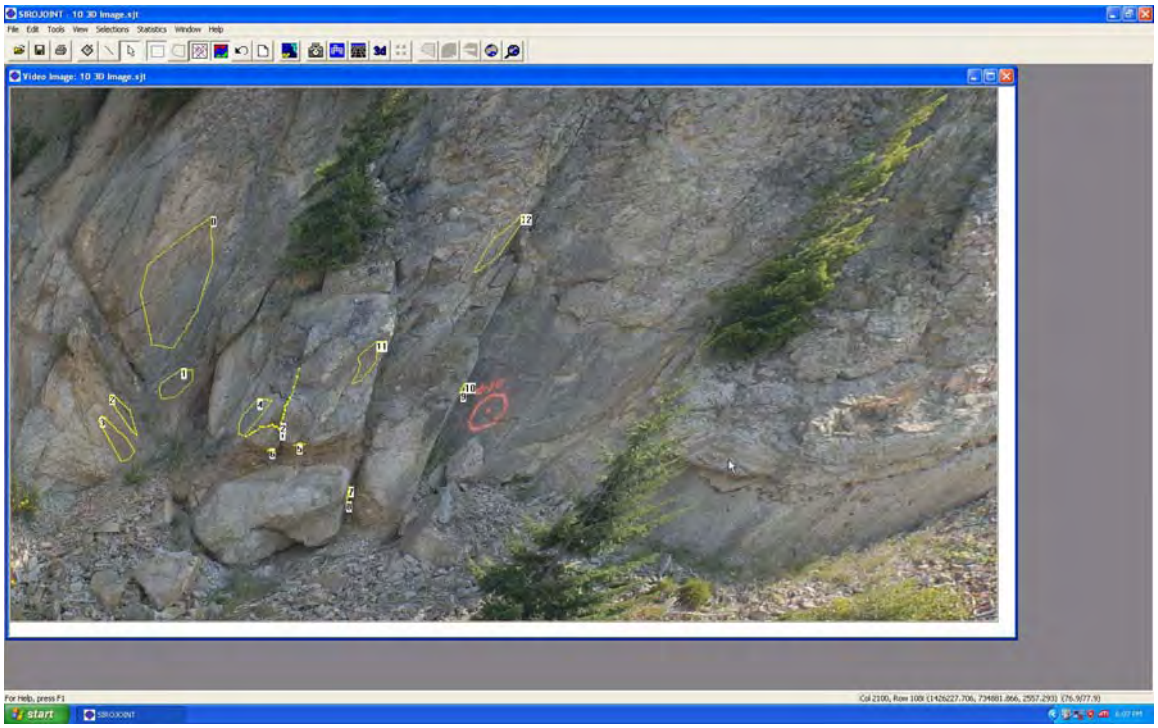
Outcrop model 2



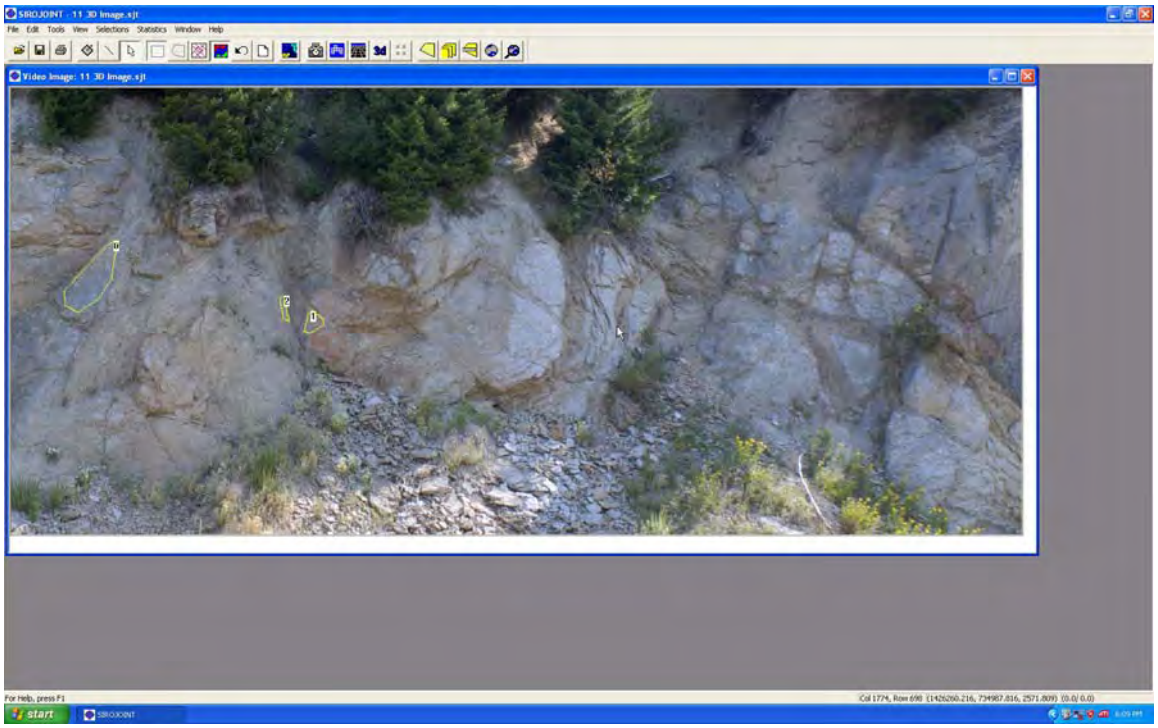
Outcrop model 3



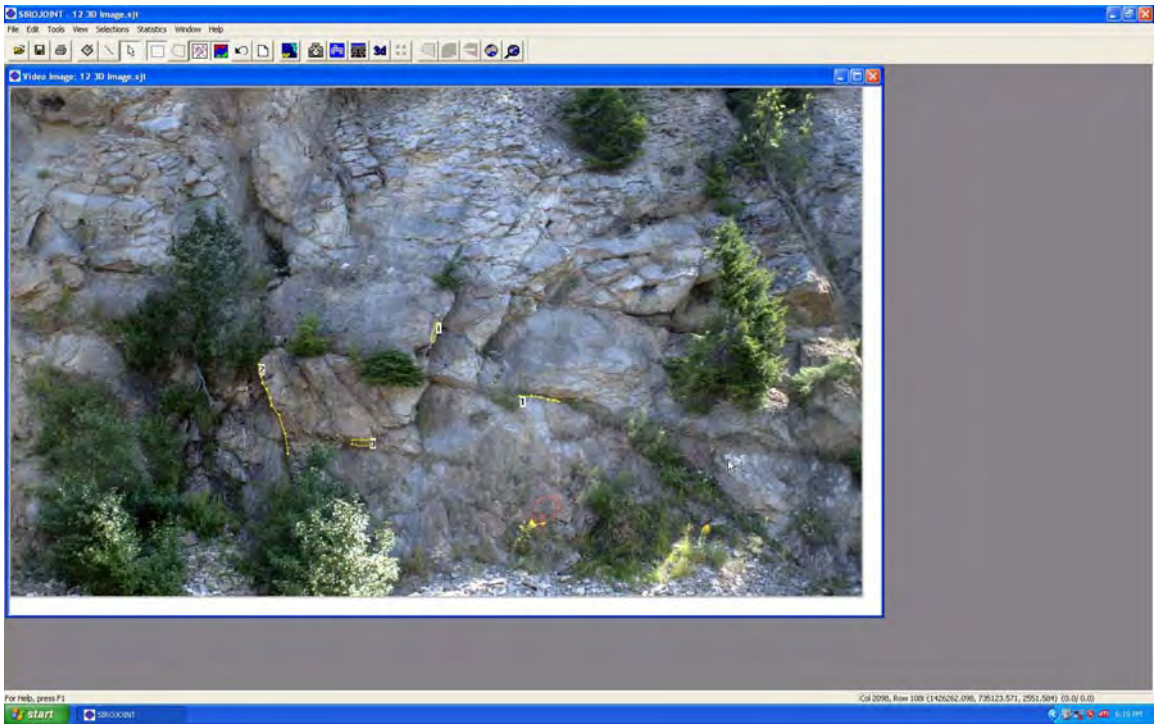
Outcrop model 4



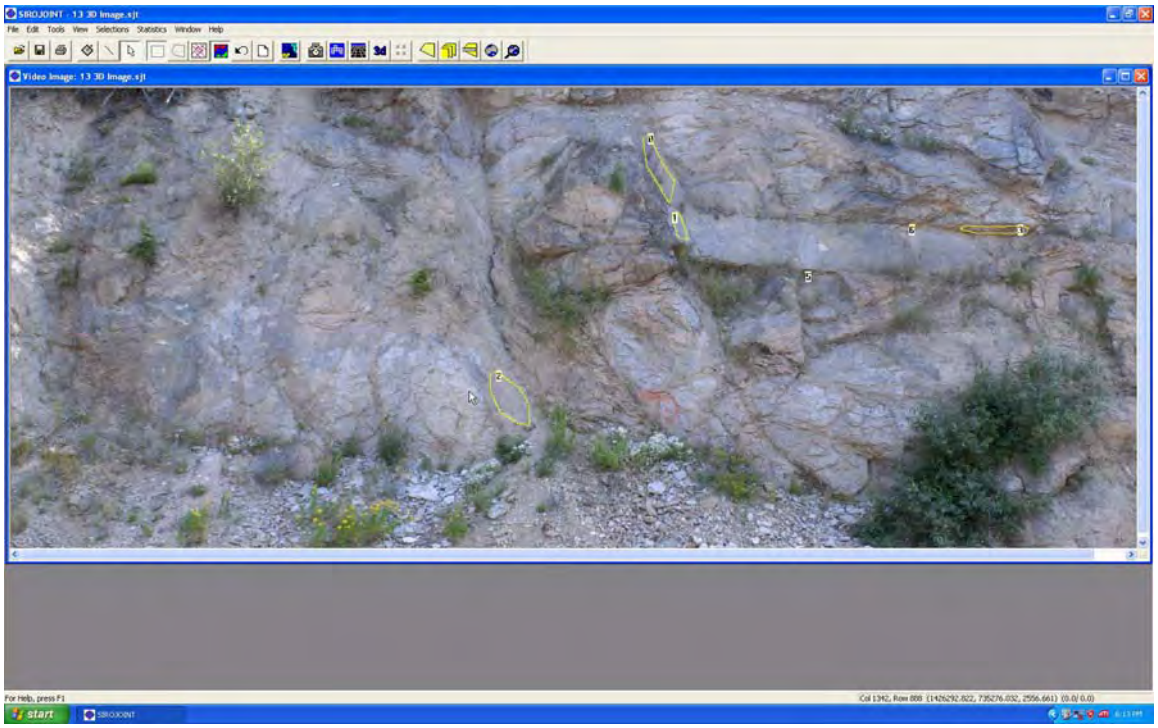
Outcrop model 10



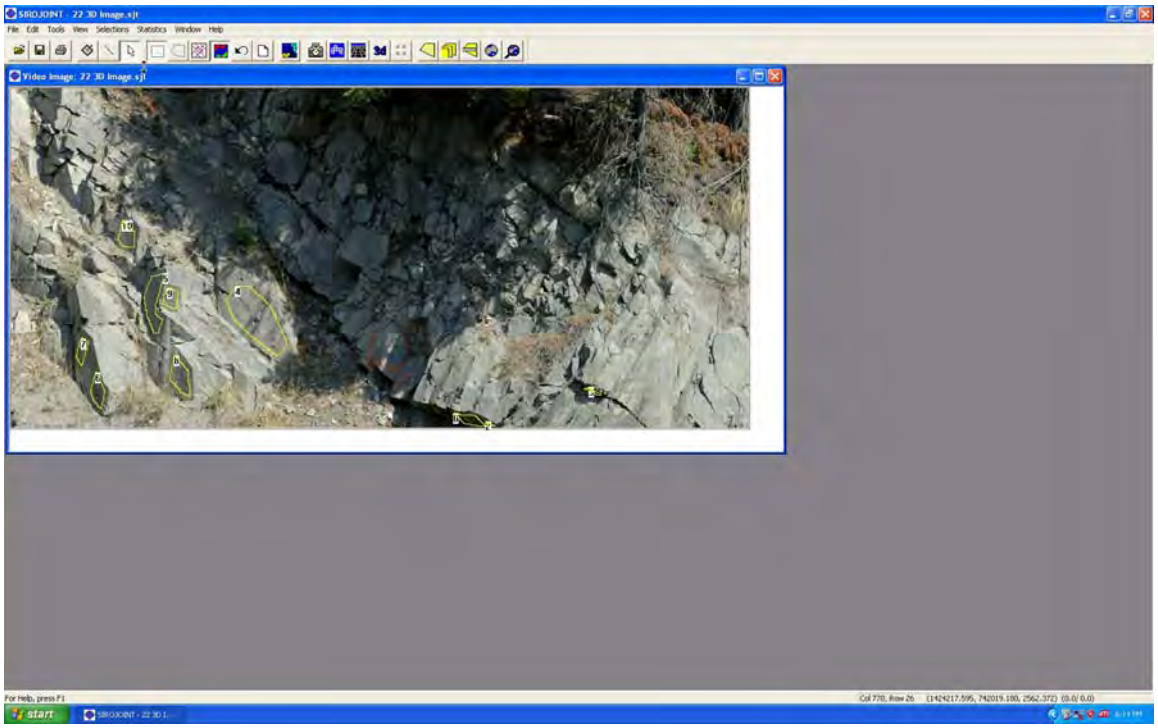
Outcrop model 11



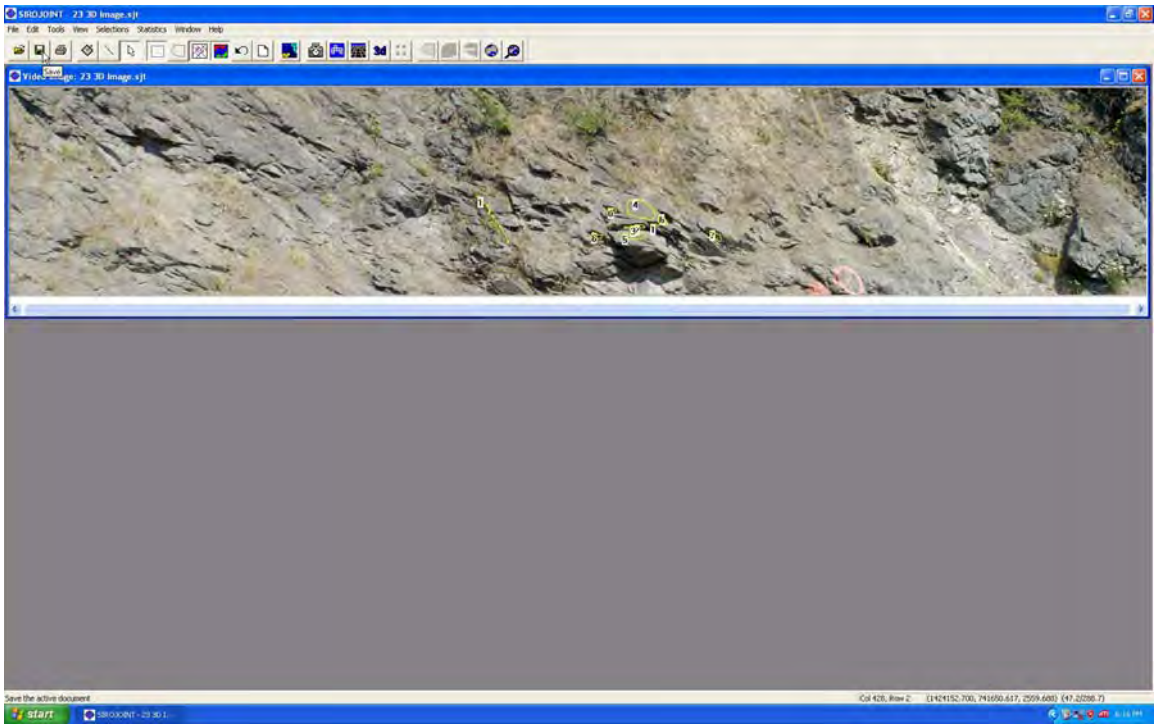
Outcrop model 12



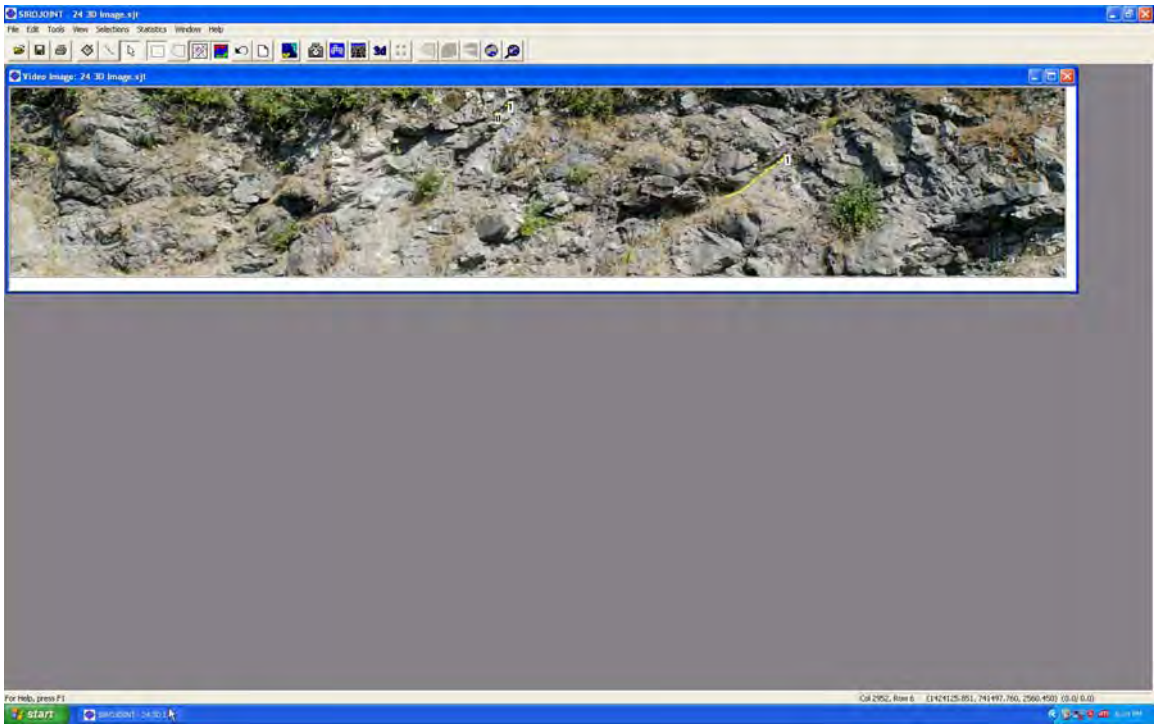
Outcrop model 13



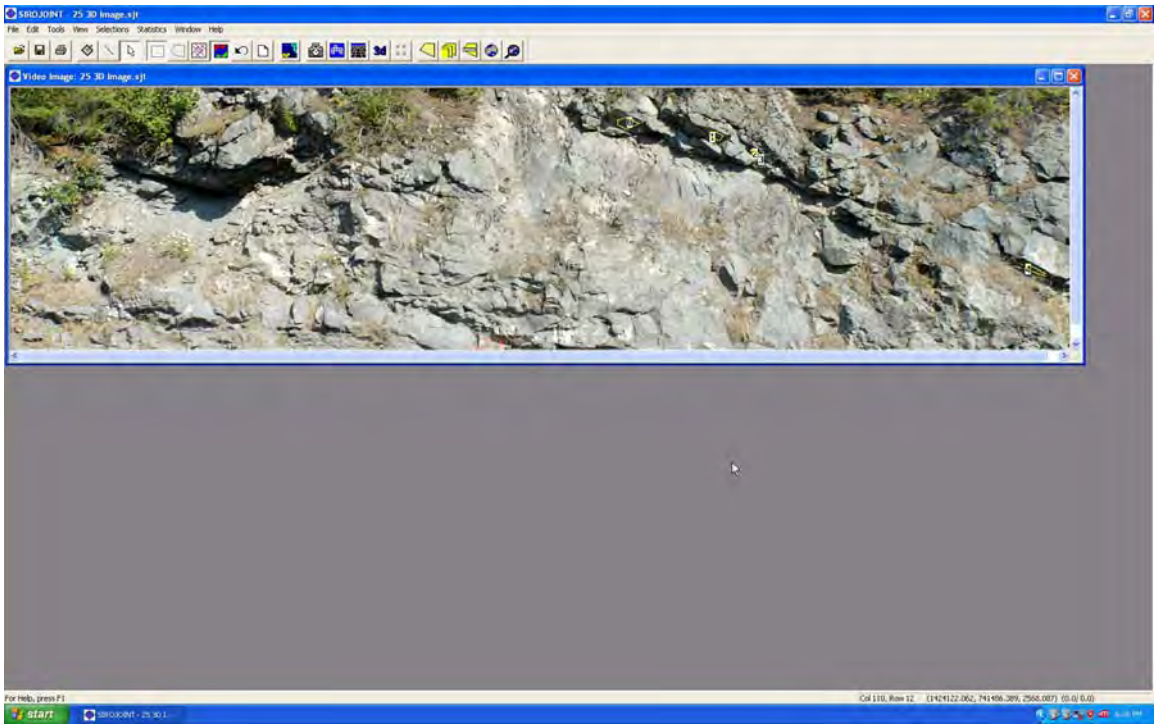
Outcrop model 22



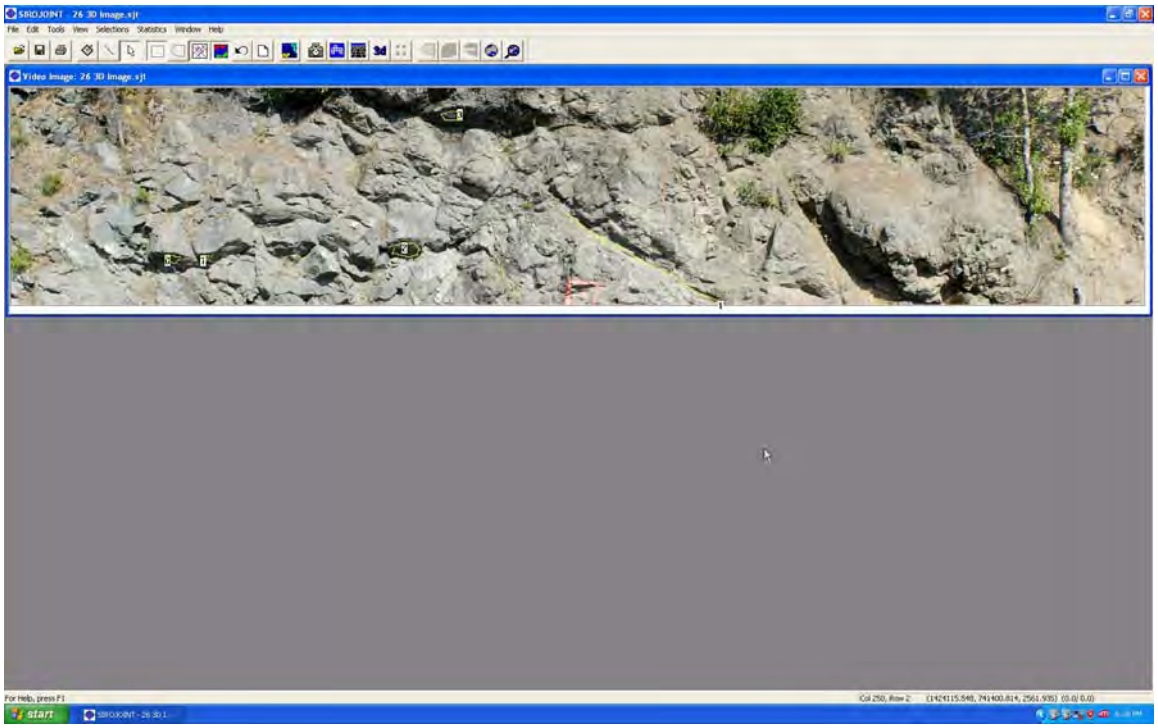
Outcrop model 23



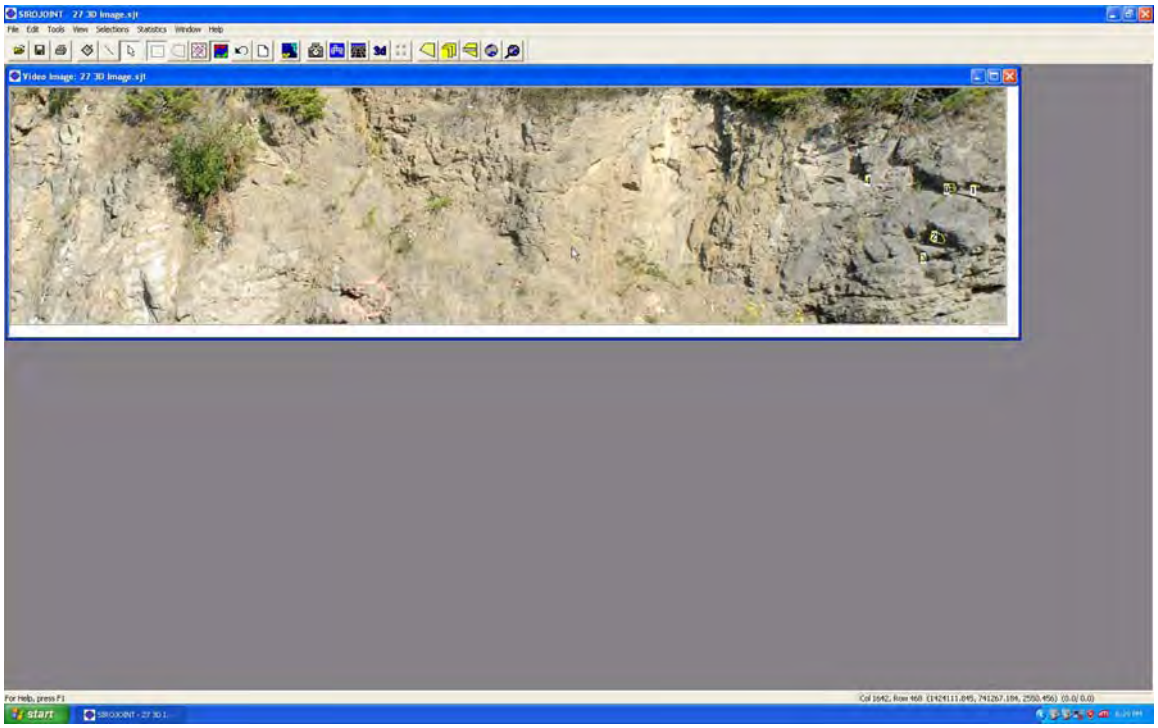
Outcrop model 24



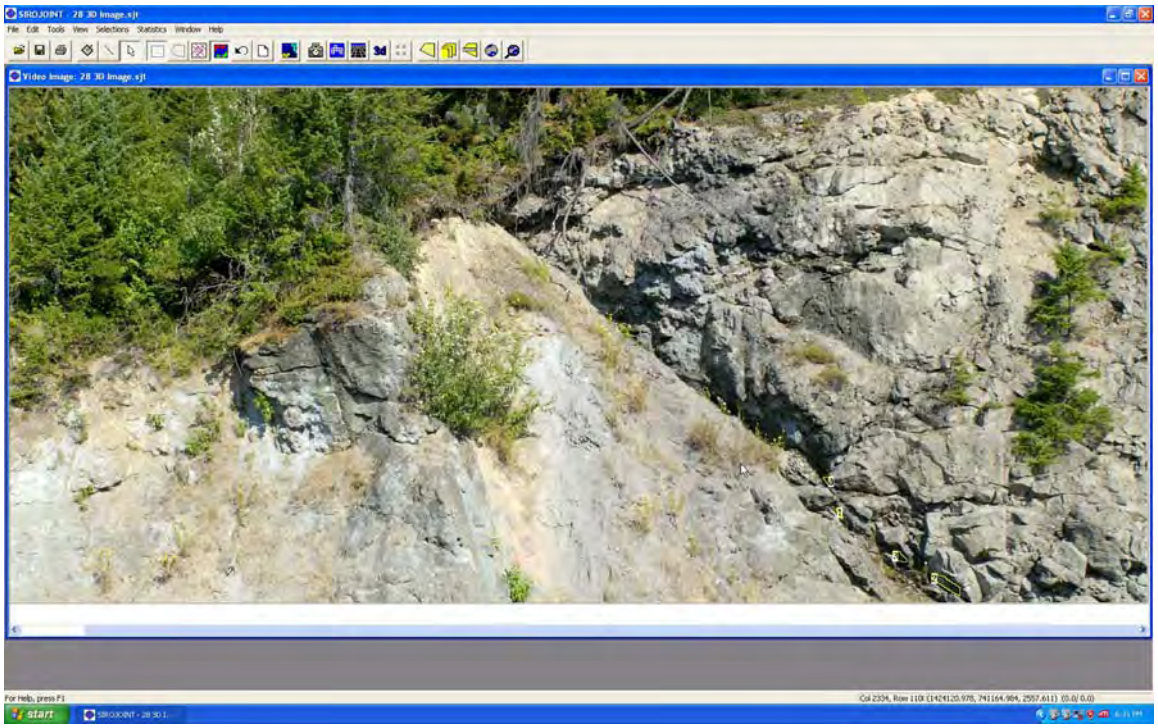
Outcrop model 25



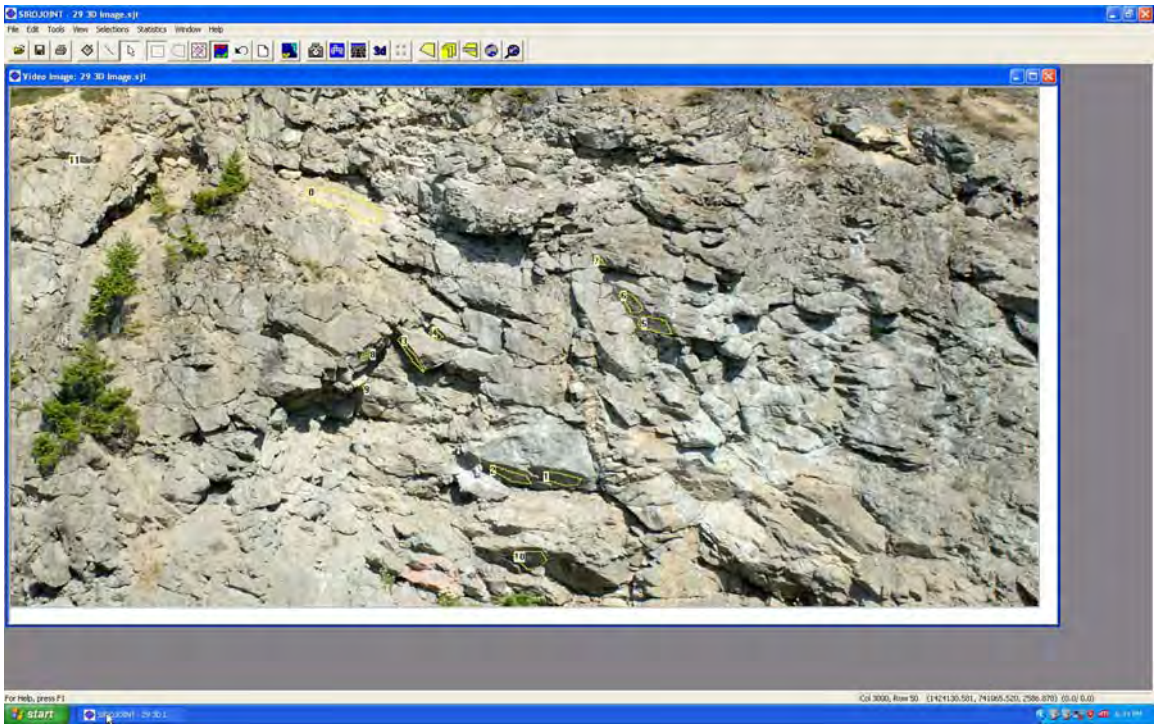
Outcrop model 26



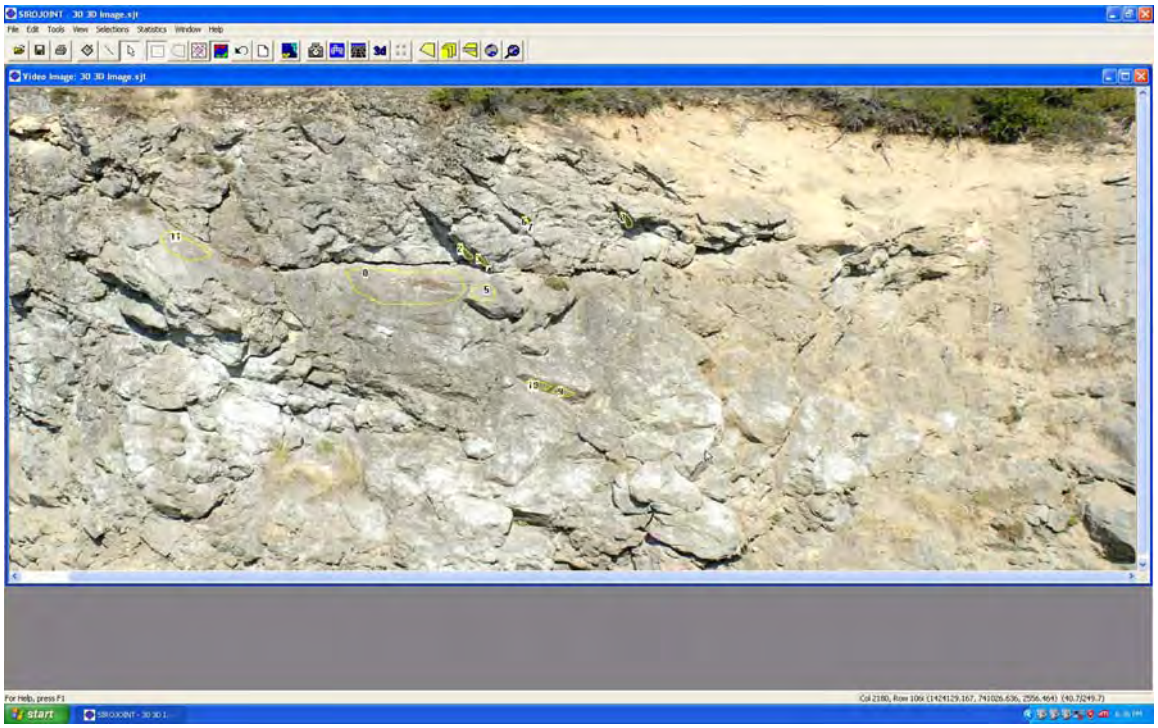
Outcrop model 27



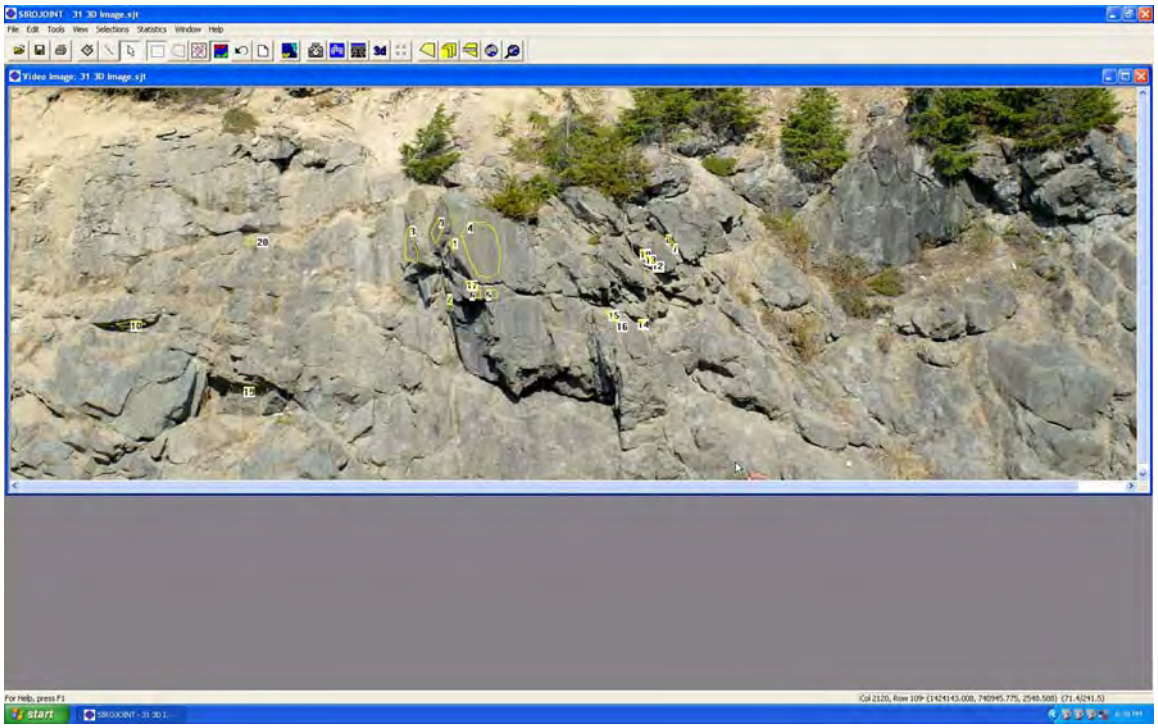
Outcrop model 28



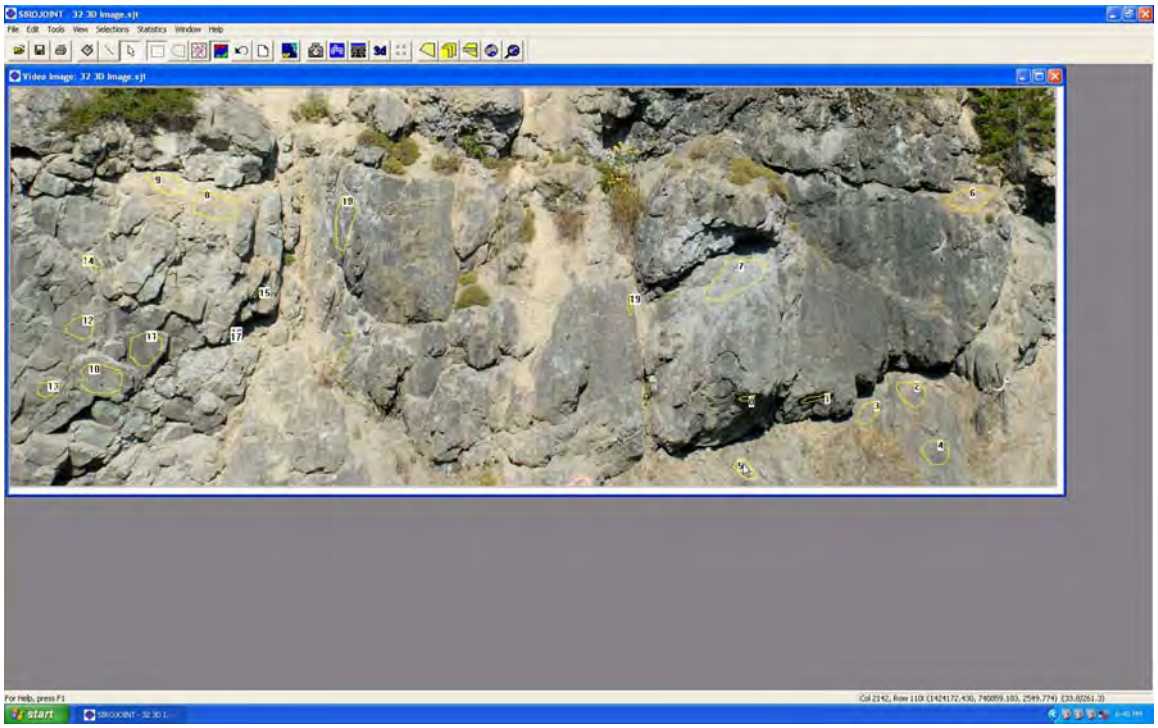
Outcrop model 29



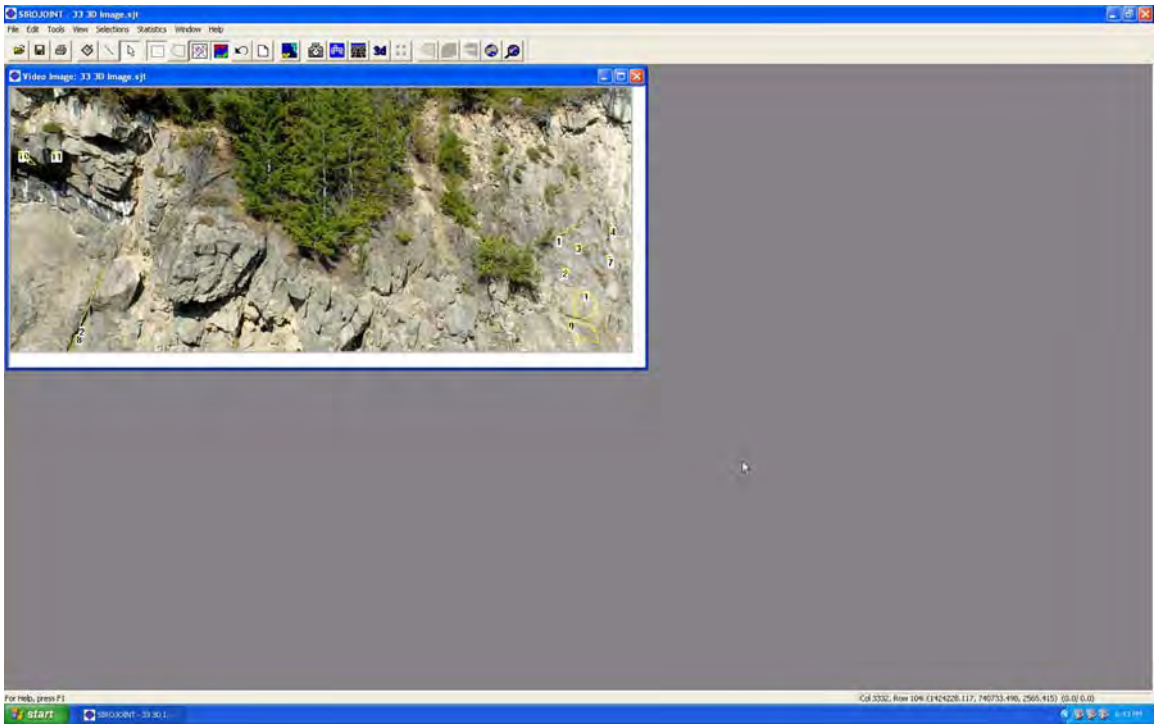
Outcrop model 30



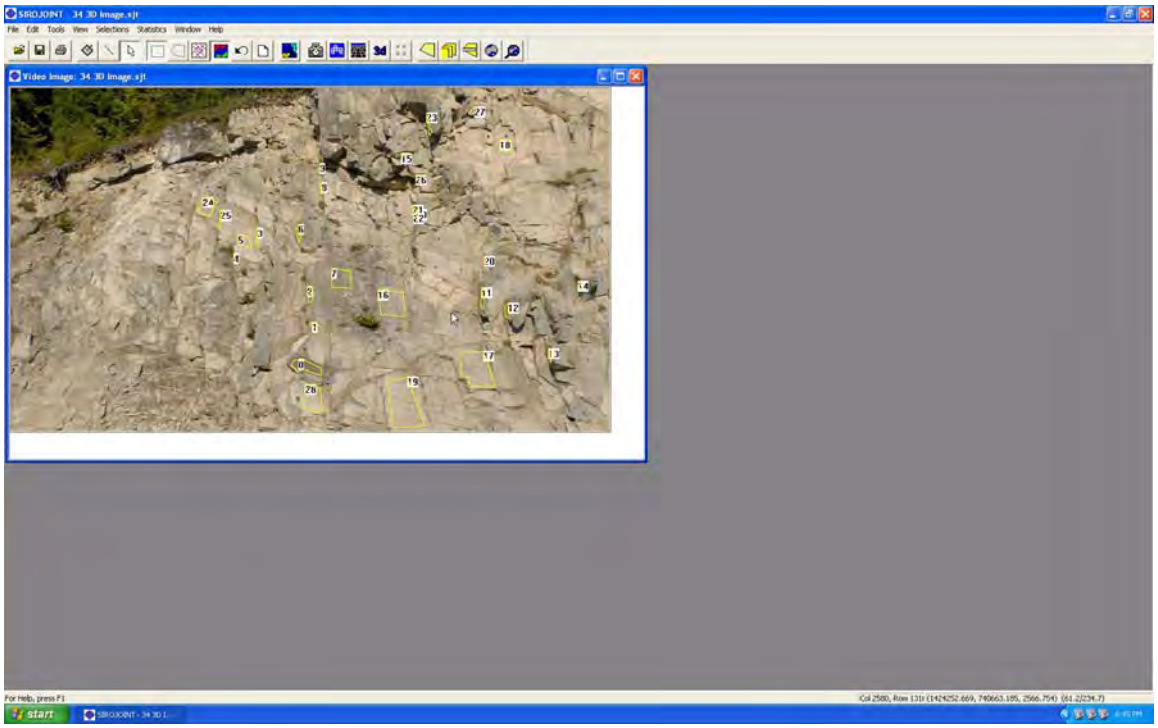
Outcrop model 31



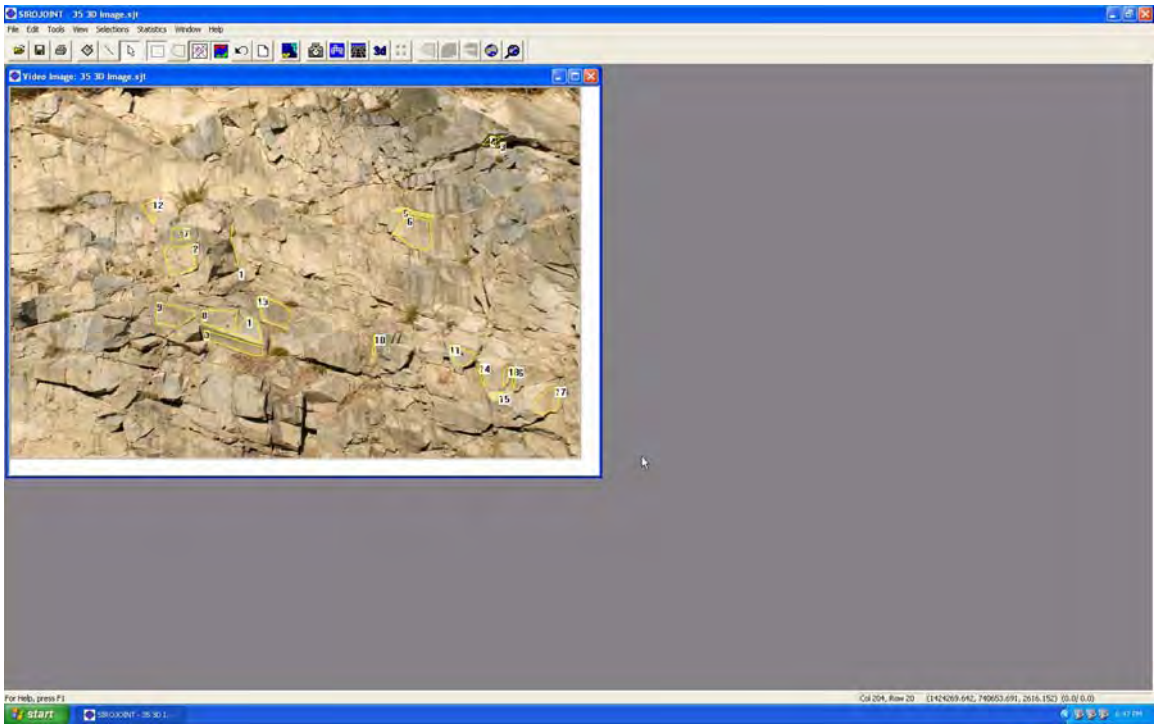
Outcrop model 32



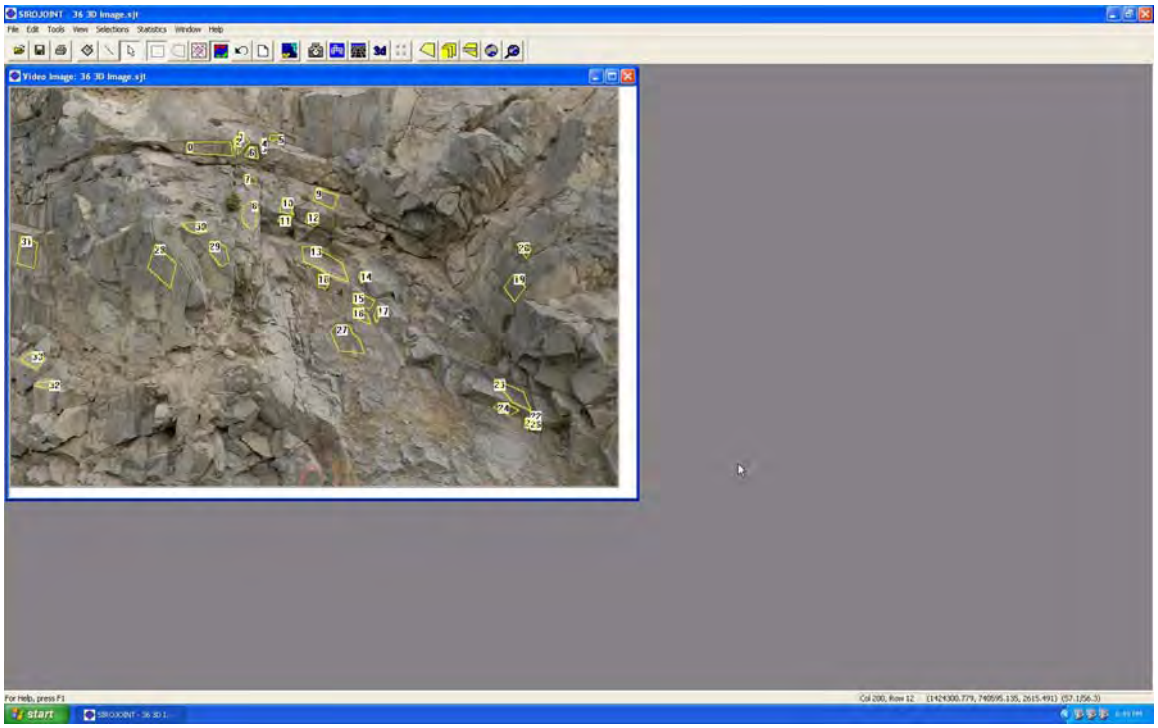
Outcrop model 33



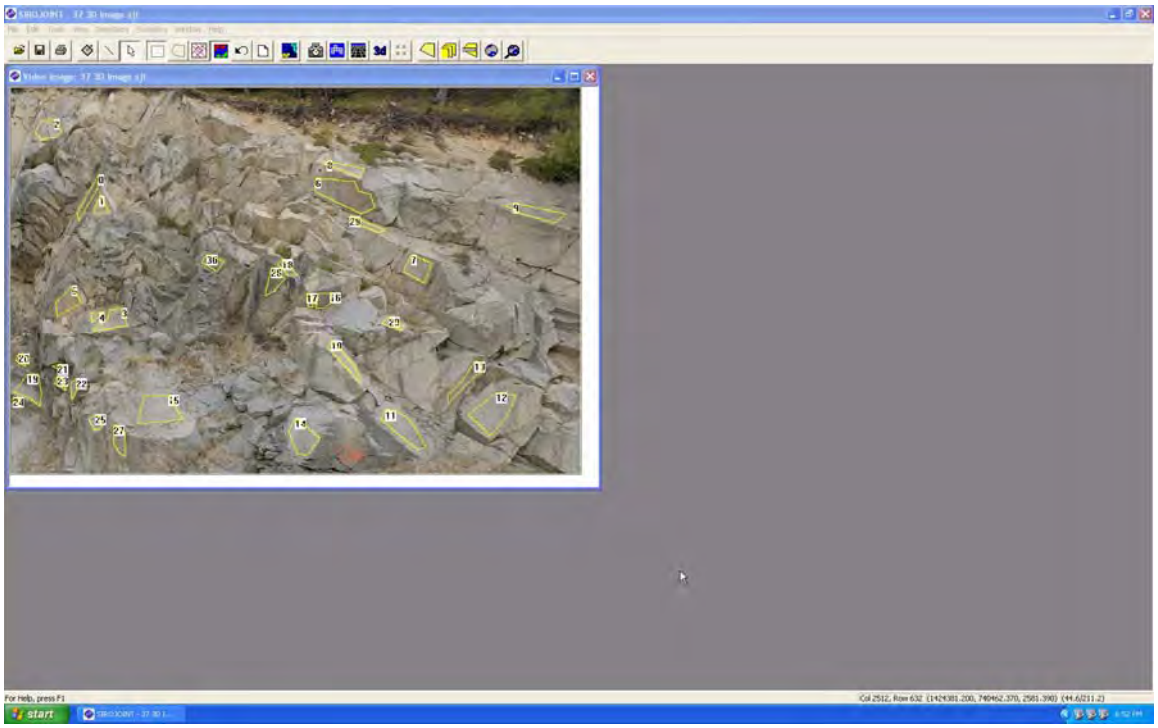
Outcrop model 34



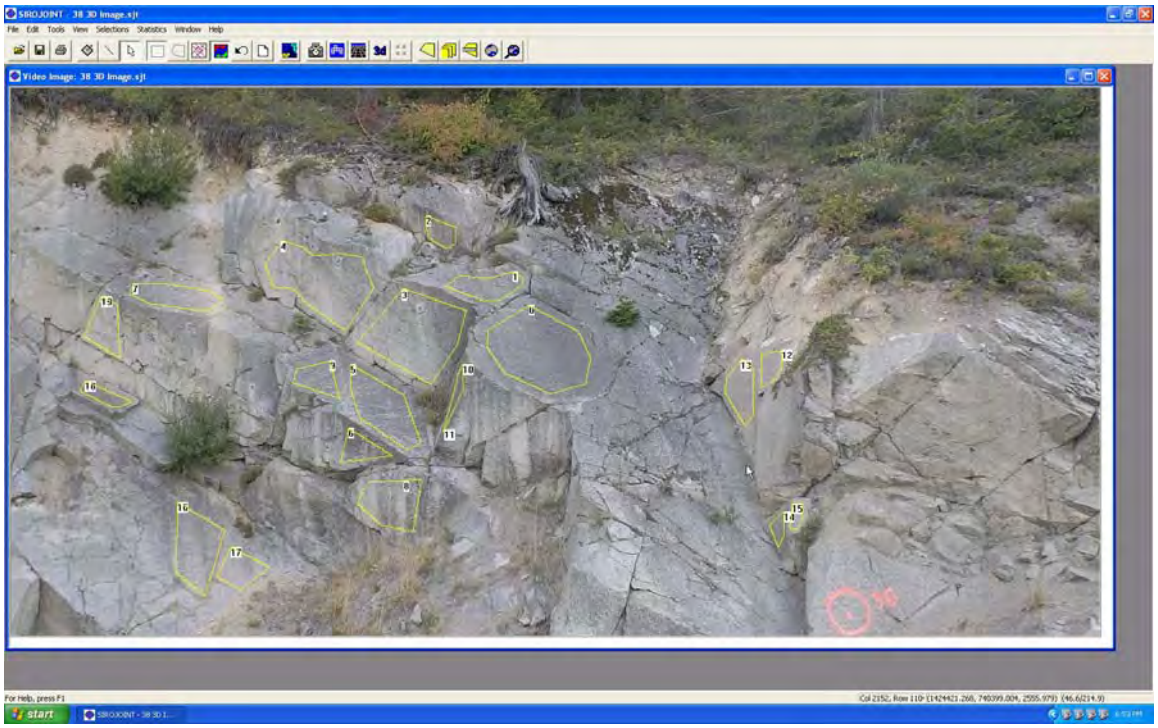
Outcrop model 35



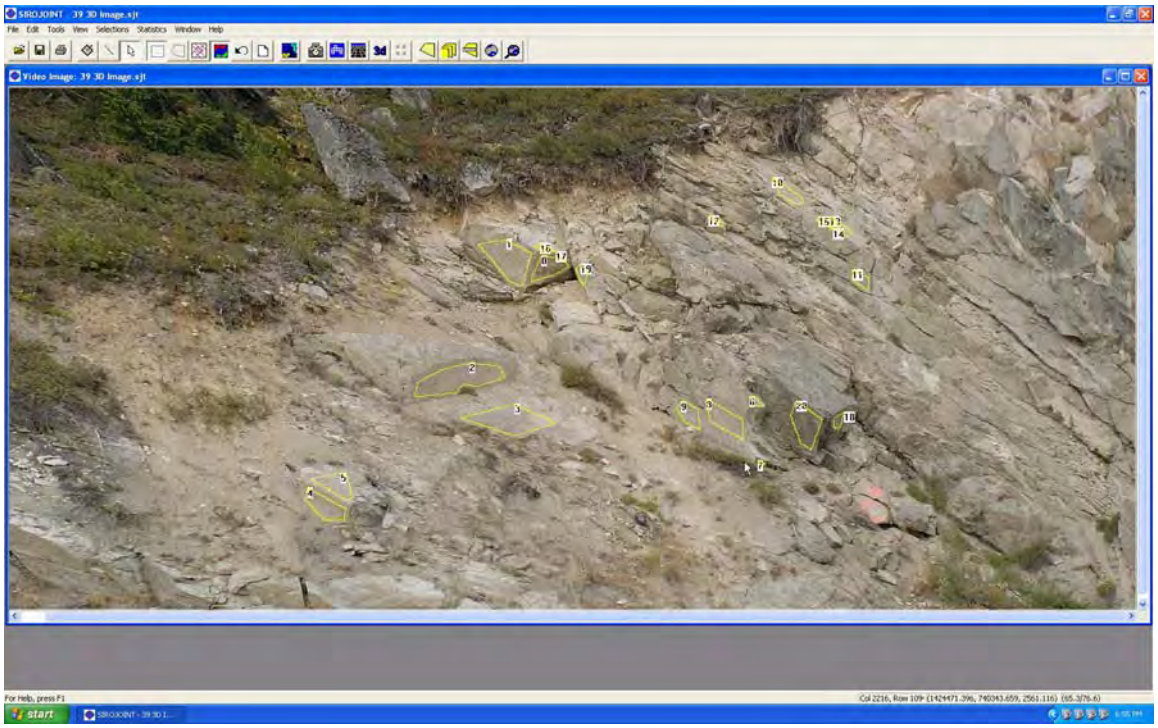
Outcrop model 36



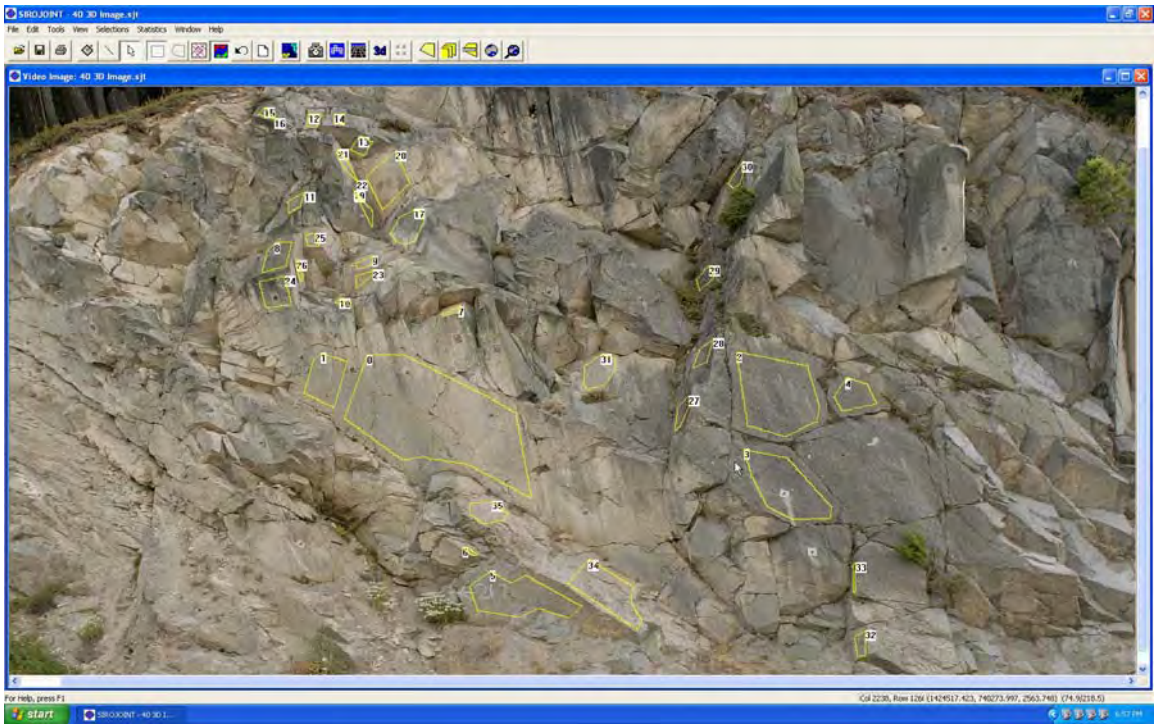
Outcrop model 37



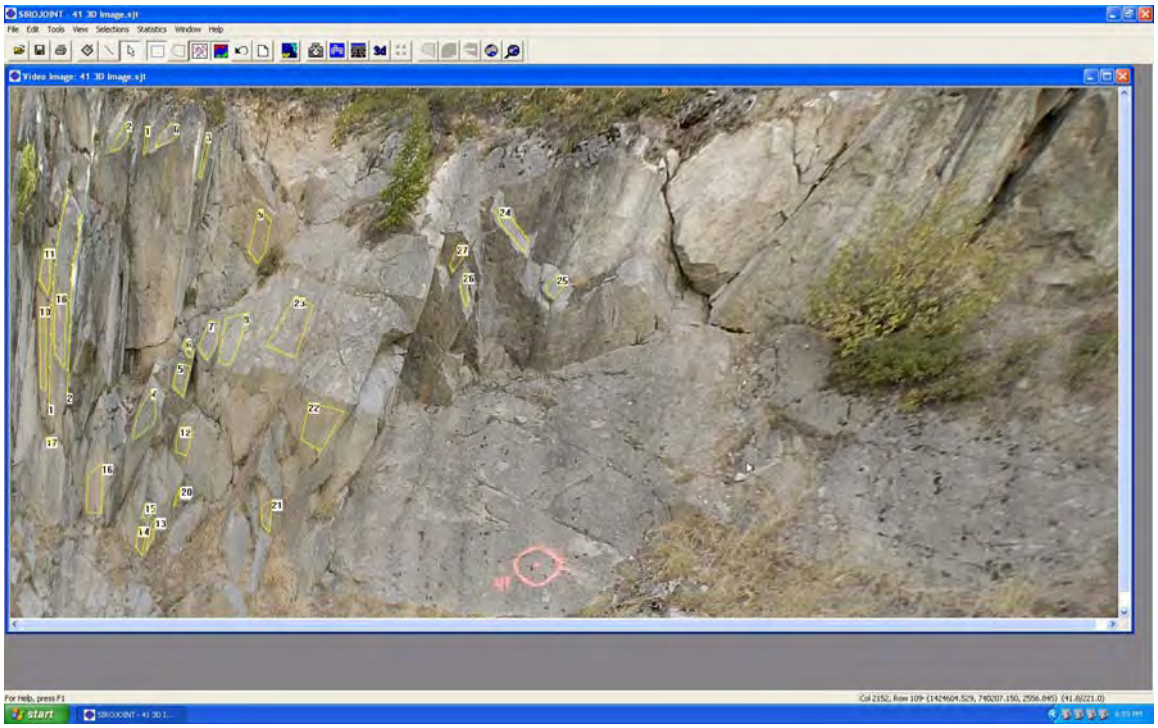
Outcrop model 38



Outcrop model 39



Outcrop model 40



Outcrop model 41

Appendix C: Structural Data from 3-D Models— Planes

This appendix contains orientation and location information for structures mapped as planes. Data for structures mapped as traces are included in Appendix D. Not all outcrop models contain trace data.

File names shown above the tables correspond to the 3-D model numbers. For example, 10_planes.xls indicates planar data from outcrop model 10.

All coordinates are in Washington State Plane South (feet), NAD83/91, NAVD88

1_planes.xls

Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	80	57.3	1426685.105	733553.249	2557.882	24.47	7.683	1426683.5	733554.603	2561.843	1426686.587	733553.105	2554.969	Unspecified	Unspecified
1	Joint Plane	81.3	62.8	1426657.065	733577.851	2559.143	277.07	47	1426647.428	733592.543	2572.589	1426667.276	733560.623	2544.372	Unspecified	Unspecified
2	Joint Plane	87.1	54.7	1426647.632	733573.754	2542.687	5.741	5.131	1426646.673	733575.047	2544.785	1426648.836	733572.247	2541.07	Unspecified	Unspecified
3	Joint Plane	32.2	165.4	1426655.97	733579.861	2568.583	1.268	1.79	1426656.387	733580.538	2568.924	1426655.819	733579.046	2568.114	Unspecified	Unspecified
4	Joint Plane	46.6	154.9	1426655.229	733580.173	2568.929	0.05	0.627	1426655.472	733580.382	2569.021	1426655.028	733579.98	2568.835	Unspecified	Unspecified
5	Joint Plane	81.5	356.2	1426655.201	733580.656	2570.622	4.261	2.767	1426654.977	733580.496	2571.931	1426655.969	733580.951	2569.389	Unspecified	Unspecified
6	Joint Plane	75.3	11.4	1426674.609	733554.462	2547.246	0.677	1.63	1426675.052	733554.168	2547.803	1426674.3	733554.663	2546.445	Unspecified	Unspecified

2_planes.xls

Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	83.1	63	1426636.059	733595.016	2553.651	111.462	27.907	1426629.666	733605.921	2559.944	1426642.537	733584.333	2547.813	Unspecified	Unspecified
1	Joint Plane	82.8	58.4	1426599.475	733626.93	2546.359	319.053	36.041	1426590.777	733642.783	2551.364	1426607.414	733611.289	2545.855	Unspecified	Unspecified
2	Joint Plane	66.6	98.5	1426616.277	733617.98	2561.225	8.034	5.1	1426616.183	733619.952	2562.784	1426616.723	733615.907	2559.726	Unspecified	Unspecified
3	Joint Plane	68.6	92.6	1426615.012	733623.926	2567.235	15.819	10.648	1426613.54	733626.388	2571.641	1426616.492	733621.407	2562.705	Unspecified	Unspecified
4	Joint Plane	57.2	355.2	1426609.638	733629.99	2566.048	2.514	2.459	1426610.057	733629.443	2567.045	1426609.045	733630.525	2565.082	Unspecified	Unspecified
5	Joint Plane	57.6	355.8	1426607.381	733630.845	2564.326	1.034	1.681	1426607.954	733630.551	2564.91	1426607.117	733631.255	2563.633	Unspecified	Unspecified
6	Joint Plane	65.1	359.6	1426602.889	733631.428	2562.761	2.353	2.356	1426603.515	733630.984	2563.719	1426602.635	733631.899	2561.734	Unspecified	Unspecified
7	Joint Plane	41.8	214.5	1426606.51	733616.497	2549.514	34.315	9.398	1426602.769	733619.582	2550.172	1426608.51	733612.493	2547.909	Unspecified	Unspecified

3_planes.xls

Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	32.5	201.3	1426557.701	733688.707	2559.82	368.639	38.62	1426548.238	733703.571	2566.595	1426569.745	733674.29	2553.5	Unspecified	Unspecified
1	Joint Plane	76.7	62.8	1426566.23	733682.547	2575.959	144.684	15.242	1426562.49	733687.531	2580.617	1426569.941	733676.827	2572.731	Unspecified	Unspecified
2	Joint Plane	73.3	345.1	1426584.928	733660.867	2591.712	7.857	5.838	1426587.257	733660.79	2593.922	1426583.803	733661.261	2589.238	Unspecified	Unspecified
3	Joint Plane	69	344.2	1426577.151	733664.8	2574.778	7.201	3.844	1426578.11	733664.46	2576.489	1426576.732	733665.448	2573.038	Unspecified	Unspecified
4	Joint Plane	63.9	236.9	1426579.563	733664.97	2565.561	15.306	7.181	1426578.213	733667.987	2566.945	1426581.278	733661.804	2564.962	Unspecified	Unspecified
5	Joint Plane	66.9	236.1	1426581.428	733664.852	2568.758	10.905	5.498	1426580.208	733667.167	2569.442	1426582.577	733662.496	2567.771	Unspecified	Unspecified
6	Joint Plane	74.6	62.6	1426549.029	733707.953	2582.625	67.635	14.512	1426551.326	733702.172	2584.371	1426546.493	733715.182	2580.134	Unspecified	Unspecified
7	Joint Plane	78.6	65.5	1426549.713	733693.388	2548.456	124.953	16.529	1426546.224	733701.256	2548.456	1426553.297	733686.653	2545.302	Unspecified	Unspecified

4_planes.xls

Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	70.1	60.5	1426522.231	733741.081	2570.447	127.241	15.526	1426517.755	733744.405	2576.035	1426525.754	733739.361	2563.721	Unspecified	Unspecified
1	Joint Plane	77.9	65.1	1426534.951	733721.36	2558.693	138.183	16.307	1426531.587	733725.432	2564.632	1426538.297	733717.555	2552.029	Unspecified	Unspecified
2	Joint Plane	43.2	207.1	1426527.573	733736.123	2577.057	0.028	0.365	1426527.724	733736.126	2577.129	1426527.403	733736.088	2576.959	Unspecified	Unspecified
3	Joint Plane	45.3	212.2	1426526.882	733739.739	2579.752	26.635	9.097	1426526.914	733743.335	2582.672	1426527.364	733736.188	2577.061	Unspecified	Unspecified
4	Joint Plane	45.2	212.6	1426520.326	733743.3	2579.28	17.058	7.835	1426519.571	733746.546	2581.476	1426521.594	733740.255	2577.266	Unspecified	Unspecified
5	Joint Plane	44.1	211	1426534.13	733741.388	2584.719	26.219	8.269	1426533.166	733744.62	2586.867	1426534.344	733738.004	2582.048	Unspecified	Unspecified

10_planes.xls

Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	76.9	77.9	1426257.769	734943.893	2578.673	86.802	12.103	1426256.878	734941.944	2584.646	1426258.844	734945.315	2573.191	Unspecified	Unspecified

1	Joint Plane	42.1	306	1426256.308	734940.284	2568.593	22.724	6.803	1426258.816	734939.739	2570.618	1426253.33	734940.049	2566.607	Unspecified	Unspecified
2	Joint Plane	46.5	224.2	1426250.515	734947.458	2564.392	16.816	7.478	1426250.19	734950.524	2566.477	1426250.093	734944.566	2561.958	Unspecified	Unspecified
3	Joint Plane	81.3	251.8	1426248.202	734947.967	2561.367	12.746	7.95	1426247.479	734951.266	2563.602	1426249.111	734944.324	2560.088	Unspecified	Unspecified
4	Joint Plane	70	348.4	1426240.497	734930.262	2562.687	23.022	8.198	1426244.906	734930.806	2563.417	1426236.847	734929.829	2562.273	Unspecified	Unspecified
5	Joint Plane	9.4	107	1426235.809	734923.933	2559.212	0.976	1.521	1426235.301	734923.333	2559.23	1426236.218	734924.544	2559.142	Unspecified	Unspecified
6	Joint Plane	6.2	46.4	1426237.166	734926.968	2558.8	0.576	1.594	1426236.523	734927.322	2558.854	1426237.74	734926.293	2558.817	Unspecified	Unspecified
7	Joint Plane	89.7	216.9	1426236.107	734915.253	2554.594	0.653	1.837	1426235.442	734915.744	2555.123	1426236.583	734914.842	2554.002	Unspecified	Unspecified
8	Joint Plane	70.1	35.9	1426236.693	734914.823	2553.747	0.019	0.341	1426236.873	734914.708	2553.713	1426236.604	734914.916	2553.683	Unspecified	Unspecified
9	Joint Plane	73.4	210.7	1426241.687	734906.024	2564.95	0.067	0.698	1426241.991	734905.861	2564.983	1426241.382	734906.188	2564.882	Unspecified	Unspecified
10	Joint Plane	79	209.6	1426242.364	734905.772	2565.519	0.487	1.727	1426243.052	734905.498	2565.885	1426241.635	734906.101	2565.105	Unspecified	Unspecified
11	Joint Plane	80.6	56.3	1426237.312	734919.539	2566.978	7.626	4.172	1426237.791	734918.373	2568.684	1426237.07	734920.333	2565.073	Unspecified	Unspecified
12	Joint Plane	76.8	51.3	1426245.78	734908.346	2577.882	10.398	5.52	1426246.814	734906.607	2579.822	1426245.158	734909.808	2575.641	Unspecified	Unspecified

11_planes.xls

Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	56.6	305.8	1426266.412	735056.871	2570.829	66.374	12.363	1426269.038	735054.352	2576.244	1426263.1	735058.294	2566.142	Unspecified	Unspecified
1	Joint Plane	78.3	298.5	1426263.187	735024.998	2568.696	4.832	2.981	1426262.49	735023.679	2568.761	1426263.555	735026.184	2567.545	Unspecified	Unspecified
2	Joint Plane	65.6	225.9	1426263.333	735029.051	2569.669	4.127	4.078	1426264.727	735029.067	2571.425	1426262.105	735029.255	2568.308	Unspecified	Unspecified

12_planes.xls

Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Bedding	29.8	116.5	1426267.634	735161.067	2553.957	2.708	2.707	1426266.942	735160.256	2554.297	1426268.87	735162.106	2553.865	Unspecified	Unspecified
1	Joint Plane	82.2	22.4	1426267.374	735154.168	2565.831	2.851	3.122	1426268.304	735153.634	2566.839	1426266.145	735154.676	2564.838	Unspecified	Unspecified

13_planes.xls

Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Fault	58.4	227.5	1426304.533	735254.147	2586.431	48.449	14.459	1426308.841	735254.648	2592.222	1426299.925	735253.649	2580.883	Unspecified	Unspecified
1	Fault	59.5	224.3	1426298.233	735252.572	2577.618	13.972	7.334	1426300.923	735251.821	2579.668	1426295.099	735253.806	2575.677	Unspecified	Unspecified
2	Fault	55	244.6	1426294.652	735271.328	2556.329	28.847	7.688	1426296.412	735272.83	2559.483	1426293.014	735269.438	2553.479	Unspecified	Unspecified
3	Bedding	50.3	109	1426291.284	735213.587	2578.814	7.784	8.801	1426289.772	735209.54	2578.971	1426292.421	735217.931	2578.789	Unspecified	Unspecified
5	Bedding	60	85.7	1426295.243	735237.287	2572.687	0.009	0.168	1426295.212	735237.269	2572.743	1426295.272	735237.373	2572.625	Unspecified	Unspecified
6	Joint Plane	65.2	100.9	1426293.602	735223.925	2579.085	0.169	0.799	1426293.434	735223.548	2579.203	1426293.711	735224.256	2578.956	Unspecified	Unspecified

22_planes.xls

Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	25.6	159.3	1424206.079	742011.069	2548.767	1.476	1.973	1424205.17	742010.987	2548.915	1424207.121	742011.05	2548.628	Unspecified	Unspecified
1	Joint Plane	31.4	169.1	1424205.011	742010.229	2548.532	0.127	0.803	1424204.587	742010.052	2548.48	1424205.378	742010.183	2548.473	Unspecified	Unspecified
2	Joint Plane	27.5	164.9	1424205.074	742010.453	2548.65	0.008	0.227	1424204.964	742010.447	2548.661	1424205.189	742010.446	2548.63	Unspecified	Unspecified
3	Joint Plane	37.4	144.4	1424202.29	742005.615	2549.932	0.142	1.053	1424202.7	742006.004	2550.028	1424202.065	742005.195	2549.799	Unspecified	Unspecified
4	Joint Plane	85.7	111.3	1424213.143	742019.875	2552.871	3.921	3.328	1424213.461	742020.879	2554.129	1424212.896	742018.931	2551.49	Unspecified	Unspecified
5	Joint Plane	88.8	151.4	1424213.727	742024.064	2553.231	1.937	2.329	1424213.992	742024.198	2554.294	1424213.243	742023.86	2552.114	Unspecified	Unspecified
6	Joint Plane	84	137.8	1424213.031	742026.073	2549.818	0.61	1.4	1424213.033	742026.178	2550.512	1424212.906	742025.912	2549.144	Unspecified	Unspecified
7	Joint Plane	89.6	155.6	1424213.659	742026.696	2551.287	0.614	1.13	1424213.156	742026.502	2551.604	1424214.085	742026.874	2551.078	Unspecified	Unspecified
8	Joint Plane	85.3	129	1424212.547	742022.981	2550.446	0.914	1.743	1424212.71	742023.258	2551.252	1424212.347	742022.583	2549.686	Unspecified	Unspecified
9	Joint Plane	71.8	99	1424213.277	742023.462	2553.436	0.359	0.874	1424213.149	742023.658	2553.8	1424213.399	742023.253	2553.067	Unspecified	Unspecified
10	Joint Plane	85	135.9	1424215.317	742025.133	2555.889	0.611	1.219	1424215.465	742025.33	2556.419	1424214.981	742024.841	2555.413	Unspecified	Unspecified

23_planes.xls

Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	89.5	123.5	1424144.999	741620.098	2551.334	0.173	0.795	1424145.23	741620.38	2551.373	1424144.694	741619.8	2551.281	Unspecified	Unspecified
1	Joint Plane	48.4	121.5	1424143.297	741617.38	2550.2	0.152	0.731	1424143.456	741617.675	2550.203	1424143.075	741617.052	2550.196	Unspecified	Unspecified
2	Joint Plane	31.8	116.2	1424143.658	741618.564	2550.097	0.324	0.854	1424143.82	741618.922	2550.125	1424143.432	741618.166	2550.044	Unspecified	Unspecified
3	Joint Plane	66.1	105.4	1424143.984	741619.471	2550.023	0.057	0.635	1424143.777	741619.26	2550.119	1424144.077	741619.799	2549.972	Unspecified	Unspecified
4	Joint Plane	47.2	288.7	1424144.492	741617.819	2551.364	4.292	2.944	1424145.6	741618.345	2552.109	1424143.289	741617.353	2550.577	Unspecified	Unspecified
5	Joint Plane	34.1	290.2	1424143.467	741619.438	2549.365	1.829	2.061	1424144	741620.304	2549.434	1424142.885	741618.579	2549.266	Unspecified	Unspecified
6	Joint Plane	62.2	243.5	1424143.65	741616.483	2550.582	0.764	1.26	1424144.051	741616.36	2550.927	1424143.07	741616.899	2550.349	Unspecified	Unspecified
7	Joint Plane	54.3	124.3	1424143.144	741612.702	2549.458	0.604	1.1	1424142.907	741613.014	2549.861	1424143.277	741612.388	2549.035	Unspecified	Unspecified
8	Joint Plane	70	119.9	1424144.837	741622.269	2549.423	0.296	0.911	1424144.948	741622.625	2549.44	1424144.497	741621.834	2549.434	Unspecified	Unspecified

24_planes.xls

Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	68.3	19	1424135.938	741538.105	2560.162	0.276	1.308	1424136.618	741537.892	2560.16	1424135.381	741538.311	2560.089	Unspecified	Unspecified
1	Joint Plane	46.3	27.2	1424136.661	741537.031	2561.02	0.152	0.694	1424136.367	741537.043	2561.138	1424137.018	741536.963	2560.91	Unspecified	Unspecified

25_planes.xls

Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	42.2	103.9	1424118.644	741441.807	2563.069	1.148	1.6	1424118.585	741442.539	2563.311	1424118.465	741440.974	2562.999	Unspecified	Unspecified
1	Joint Plane	38.6	104.5	1424117.309	741435.678	2561.694	0.597	1.246	1424117.006	741436.159	2561.961	1424117.705	741435.308	2561.377	Unspecified	Unspecified
2	Joint Plane	45.8	146.6	1424117.588	741432.811	2560.481	0.129	0.662	1424117.696	741433.082	2560.62	1424117.516	741432.543	2560.28	Unspecified	Unspecified
3	Joint Plane	32.1	147.5	1424117.536	741432.508	2560.252	0.01	0.182	1424117.45	741432.489	2560.268	1424117.624	741432.512	2560.221	Unspecified	Unspecified
4	Joint Plane	82.5	294	1424112.941	741415.159	2551.14	0.323	1.414	1424113.118	741415.688	2551.567	1424112.536	741414.601	2550.874	Unspecified	Unspecified

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Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN

0	Joint Plane	29.9	102.5	1424108.918	741394.157	2549.107	0.86	1.273	1424108.738	741393.489	2549.203	1424109.185	741394.674	2549.078	Unspecified	Unspecified
1	Joint Plane	47.6	110.7	1424108.83	741391.755	2549.138	0.214	0.865	1424108.625	741391.344	2549.243	1424109.062	741392.062	2549.038	Unspecified	Unspecified
2	Joint Plane	40.9	79.7	1424109.26	741377.077	2549.436	2.31	2.04	1424109.39	741376.135	2549.448	1424109.486	741378.156	2549.193	Unspecified	Unspecified
3	Joint Plane	42.5	115.9	1424110.977	741373.479	2558.773	1.173	1.784	1424110.333	741372.998	2559.098	1424111.676	741374.039	2558.554	Unspecified	Unspecified

27_planes.xls

Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	44.9	150.2	1424112.369	741242.981	2554.075	0.247	0.839	1424112.586	741243.295	2554.232	1424112.181	741242.653	2553.874	Unspecified	Unspecified
1	Joint Plane	50.3	141.9	1424111.699	741241.767	2554.006	0.068	0.586	1424111.422	741241.609	2553.998	1424111.912	741241.929	2553.97	Unspecified	Unspecified
2	Joint Plane	47.6	147.2	1424111.131	741243.164	2550.788	0.753	1.225	1424111.177	741243.622	2551.204	1424111.01	741242.709	2550.405	Unspecified	Unspecified
3	Joint Plane	56.9	143.7	1424111.277	741243.593	2549.591	0.159	0.587	1424111.389	741243.749	2549.832	1424111.222	741243.358	2549.428	Unspecified	Unspecified
4	Joint Plane	71.7	174.7	1424114.422	741247.631	2554.811	0.098	0.579	1424114.631	741247.694	2554.985	1424114.201	741247.549	2554.624	Unspecified	Unspecified

29_planes.xls

Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Fault	51.2	144	1424122.02	741157.881	2556.572	0.254	0.874	1424121.655	741157.863	2556.795	1424122.351	741157.765	2556.274	Unspecified	Unspecified
1	Fault	76.5	140.4	1424122.59	741156.821	2553.991	0.158	0.951	1424122.495	741156.964	2554.444	1424122.405	741156.611	2553.565	Unspecified	Unspecified
2	Fault	63.5	142.9	1424120.475	741149.272	2548.705	2.017	2.586	1424121.098	741150.126	2549.479	1424120.093	741148.416	2547.821	Unspecified	Unspecified
3	Fault	50.6	131.4	1424121.618	741152.462	2550.724	0.755	1.31	1424121.607	741152.951	2551.153	1424121.545	741151.954	2550.305	Unspecified	Unspecified

29_planes.xls

Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	47.4	252.3	1424127.459	741119.971	2580.359	16.246	7.386	1424127.792	741123.269	2581.894	1424126.746	741116.689	2578.705	Unspecified	Unspecified
1	Joint Plane	35.4	100.8	1424127.545	741101.27	2558.716	3.189	3.014	1424127.093	741102.664	2559.171	1424127.186	741099.687	2558.71	Unspecified	Unspecified
2	Joint Plane	34.2	106.4	1424127.858	741105.325	2558.915	3.312	3.804	1424127.091	741106.916	2559.546	1424128.48	741103.587	2558.339	Unspecified	Unspecified
3	Joint Plane	46.9	148	1424126.063	741113.639	2567.816	2.179	3.413	1424125.203	741114.367	2569.136	1424126.564	741112.572	2566.572	Unspecified	Unspecified
4	Joint Plane	50.5	125.5	1424125.67	741111.635	2569.405	0.782	1.386	1424125.963	741112.217	2569.501	1424125.456	741110.996	2569.086	Unspecified	Unspecified
5	Joint Plane	58.5	125.9	1424124.992	741094.399	2569.738	2.82	2.883	1424125.551	741095.661	2570.177	1424124.493	741093.222	2569.058	Unspecified	Unspecified
6	Joint Plane	61.8	124	1424125.079	741096.333	2571.591	1.949	2.204	1424125.179	741097.051	2572.416	1424124.877	741095.424	2570.959	Unspecified	Unspecified
7	Joint Plane	53.6	135.2	1424124.503	741098.826	2574.545	0.443	1.098	1424124.542	741099.182	2574.932	1424124.384	741098.393	2574.185	Unspecified	Unspecified
8	Joint Plane	44.4	21.9	1424123.376	741117.097	2567.452	0.419	1.15	1424123.929	741116.834	2567.496	1424122.946	741117.408	2567.333	Unspecified	Unspecified
9	Joint Plane	47.9	7.7	1424125.308	741117.445	2565.245	0.125	0.88	1424124.969	741117.526	2565.203	1424125.844	741117.442	2565.17	Unspecified	Unspecified
10	Joint Plane	37	96.2	1424126.803	741103.679	2552.672	4.242	2.705	1424125.81	741102.724	2553.197	1424127.918	741103.85	2551.93	Unspecified	Unspecified
11	Joint Plane	44	98.7	1424124.317	741144.652	2584.145	0.22	0.643	1424124.177	741144.35	2584.212	1424124.429	741144.919	2584.048	Unspecified	Unspecified

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Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	40.7	249.7	1424131.62	741047.247	2570.27	44.243	9.283	1424131.207	741051.593	2571.68	1424132.398	741042.612	2569.66	Unspecified	Unspecified
1	Joint Plane	59.9	144.6	1424134.92	741042.727	2572.874	1.016	1.521	1424134.854	741043.169	2573.391	1424134.726	741042.172	2572.25	Unspecified	Unspecified
2	Joint Plane	59.2	152.7	1424134.697	741043.168	2573.485	0.018	0.332	1424134.546	741043.086	2573.478	1424134.843	741043.236	2573.474	Unspecified	Unspecified

3	Joint Plane	63.4	141.3	1424134.017	741041.439	2571.963	0.559	1.195	1424134.017	741041.744	2572.459	1424133.993	741041.086	2571.462	Unspecified	Unspecified
4	Joint Plane	48.6	129.5	1424134.008	741041.061	2571.431	0.01	0.186	1424133.942	741040.997	2571.444	1424134.082	741041.113	2571.404	Unspecified	Unspecified
5	Joint Plane	43.9	263.7	1424131.843	741041.164	2569.099	2.938	2.26	1424132.707	741041.212	2569.877	1424131.063	741040.857	2568.368	Unspecified	Unspecified
6	Joint Plane	51.7	105.5	1424135.441	741037.851	2574.877	0.071	0.578	1424135.355	741038.035	2575.064	1424135.544	741037.651	2574.676	Unspecified	Unspecified
7	Joint Plane	74.2	85.9	1424135.556	741037.626	2574.644	0.006	0.111	1424135.554	741037.575	2574.669	1424135.566	741037.665	2574.605	Unspecified	Unspecified
8	Joint Plane	51.4	129.8	1424137.708	741030.554	2574.468	0.751	1.408	1424137.328	741030.723	2574.992	1424138.293	741030.66	2573.968	Unspecified	Unspecified
9	Joint Plane	64.2	97.8	1424130.28	741036.056	2561.255	0.715	1.752	1424130.3	741036.91	2561.296	1424130.083	741035.184	2561.079	Unspecified	Unspecified
10	Joint Plane	63.6	95.9	1424129.921	741037.731	2561.905	0.777	1.888	1424129.977	741038.631	2562.132	1424129.935	741036.794	2561.697	Unspecified	Unspecified
11	Joint Plane	41.3	226.4	1424125.977	741062.743	2573.728	11.588	5.024	1424127.211	741064.21	2575.351	1424124.008	741061.895	2572.248	Unspecified	Unspecified

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Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	76.7	313.9	1424145.117	740969.156	2566.648	2.051	2.533	1424145.913	740969.381	2567.704	1424144.543	740968.892	2565.63	Unspecified	Unspecified
1	Joint Plane	88.1	322.5	1424143.884	740967.402	2565.258	0.622	1.536	1424144.556	740967.885	2565.404	1424143.432	740967.072	2564.742	Unspecified	Unspecified
2	Joint Plane	83.8	145.2	1424145.752	740968	2561.112	0.786	1.706	1424146.228	740968.417	2561.773	1424145.507	740967.694	2560.407	Unspecified	Unspecified
3	Joint Plane	83.2	141.8	1424146.322	740971.699	2565.764	5.758	3.512	1424147.263	740972.481	2567.029	1424145.614	740970.794	2564.428	Unspecified	Unspecified
4	Joint Plane	71.4	241.5	1424144.081	740965.097	2564.859	10.989	5.043	1424144.439	740966.354	2567.043	1424143.652	740964.197	2562.553	Unspecified	Unspecified
5	Joint Plane	77.2	244.3	1424143.464	740964	2561.278	0.561	1.081	1424143.328	740964.38	2561.606	1424143.661	740963.571	2560.972	Unspecified	Unspecified
6	Joint Plane	85.9	241.4	1424142.94	740965.141	2561.316	0.525	1.018	1424142.882	740965.529	2561.633	1424143.176	740964.788	2561	Unspecified	Unspecified
7	Joint Plane	54.1	121.4	1424150.883	740951.446	2564.992	0.06	0.42	1424150.838	740951.553	2565.145	1424150.995	740951.333	2564.825	Unspecified	Unspecified
8	Joint Plane	57.5	129.4	1424150.735	740951.84	2565.521	0.215	0.942	1424150.628	740952.094	2565.887	1424150.838	740951.553	2565.145	Unspecified	Unspecified
9	Joint Plane	48.6	145.5	1424149.351	740953.146	2563.919	0.169	0.709	1424149.497	740953.405	2564.063	1424149.166	740952.86	2563.752	Unspecified	Unspecified
10	Joint Plane	46.3	134.9	1424149.694	740953.774	2564.456	0.166	0.722	1424149.883	740954.047	2564.47	1424149.464	740953.483	2564.305	Unspecified	Unspecified
11	Joint Plane	55.1	143.8	1424149.127	740952.69	2563.516	0.044	0.414	1424148.925	740952.576	2563.549	1424149.274	740952.796	2563.521	Unspecified	Unspecified
12	Joint Plane	69.8	149.9	1424149.221	740952.836	2563.645	0.018	0.277	1424149.074	740952.763	2563.656	1424149.318	740952.885	2563.611	Unspecified	Unspecified
13	Joint Plane	73.4	154	1424149.442	740953.445	2564.188	0.022	0.331	1424149.274	740953.367	2564.196	1424149.574	740953.501	2564.158	Unspecified	Unspecified
14	Joint Plane	59	76	1424147.793	740953.397	2558.965	0.073	0.639	1424147.598	740953.609	2559.107	1424147.932	740953.118	2558.872	Unspecified	Unspecified
15	Joint Plane	35.6	227.5	1424146.332	740955.446	2559.411	0.686	1.805	1424147.054	740955.799	2559.881	1424145.741	740955.037	2558.905	Unspecified	Unspecified
16	Joint Plane	35.5	211.5	1424145.833	740954.868	2558.872	0.017	0.297	1424145.957	740954.848	2558.909	1424145.676	740954.867	2558.816	Unspecified	Unspecified
17	Joint Plane	82.7	268	1424143.297	740965.604	2562.131	0.15	0.992	1424143.443	740965.984	2562.407	1424143.304	740965.112	2561.955	Unspecified	Unspecified
18	Joint Plane	30.2	82.2	1424141.429	740992.91	2560.374	1.26	2.411	1424141.205	740994.045	2560.377	1424141.431	740991.645	2560.349	Unspecified	Unspecified
19	Joint Plane	20.6	91.6	1424142.604	740982.869	2554.912	0.801	1.314	1424141.906	740982.941	2555.093	1424143.131	740982.649	2554.716	Unspecified	Unspecified
20	Joint Plane	44.7	259.7	1424147.725	740986.19	2567.294	0.763	1.257	1424148.192	740986.724	2567.614	1424147.405	740986	2566.953	Unspecified	Unspecified

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Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	22.3	73.7	1424170.017	740858.502	2554.049	0.649	1.446	1424170.013	740857.786	2554.191	1424170.093	740859.212	2553.96	Unspecified	Unspecified
1	Joint Plane	25.7	69.2	1424176.323	740853.346	2553.992	1.371	2.437	1424176.251	740852.194	2554.112	1424176.119	740854.598	2553.742	Unspecified	Unspecified
2	Joint Plane	43.1	273.8	1424179.635	740845.013	2554.278	5.53	3.32	1424180.523	740846.28	2555.025	1424178.689	740843.91	2553.595	Unspecified	Unspecified
3	Joint Plane	42.8	265.3	1424178.391	740848.99	2552.929	2.934	2.777	1424179.439	740848.365	2553.789	1424177.711	740850.002	2552.359	Unspecified	Unspecified
4	Joint Plane	45.7	268.3	1424175.178	740843.067	2550.069	4.598	2.722	1424176.117	740841.997	2550.725	1424174.427	740843.543	2549.256	Unspecified	Unspecified
5	Joint Plane	33.8	261.3	1424171.928	740858.913	2549.395	2.619	2.704	1424172.859	740859.575	2550.089	1424171.189	740857.867	2548.821	Unspecified	Unspecified
6	Joint Plane	43.3	270.3	1424184.706	740838.621	2569.367	9.41	4.605	1424184.823	740836.406	2569.613	1424184.275	740840.946	2569.078	Unspecified	Unspecified
7	Joint Plane	42.3	278.5	1424173.365	740859.798	2562.294	16.91	5.779	1424174.585	740857.581	2563.47	1424172.262	740862.162	2560.822	Unspecified	Unspecified
8	Joint Plane	44.7	241.1	1424162.233	740896.224	2566.13	6.66	3.471	1424162.832	740897.435	2567.212	1424162.006	740894.611	2565.37	Unspecified	Unspecified
9	Joint Plane	42.4	236.5	1424161.862	740899.619	2567.441	3.341	2.879	1424161.826	740900.96	2567.958	1424161.872	740898.315	2566.82	Unspecified	Unspecified
10	Joint Plane	71.3	65.2	1424159.401	740901.419	2555.938	3.317	2.508	1424158.768	740902.387	2556.38	1424160.085	740900.549	2555.298	Unspecified	Unspecified
11	Joint Plane	69.4	69.5	1424160.227	740899.191	2557.648	3.047	2.143	1424159.912	740899.018	2558.604	1424160.564	740899.685	2556.675	Unspecified	Unspecified
12	Joint Plane	74	66	1424158.664	740902.587	2558.74	1.552	1.634	1424158.851	740901.851	2558.937	1424158.404	740903.397	2558.652	Unspecified	Unspecified
13	Joint Plane	73.9	61.7	1424158.42	740904.2	2555.439	0.71	1.313	1424158.656	740903.548	2555.615	1424158.194	740904.698	2555.184	Unspecified	Unspecified
14	Joint Plane	52.2	221.5	1424158.224	740902.086	2562.336	0.52	1.411	1424158.233	740902.613	2562.77	1424158.13	740901.579	2561.815	Unspecified	Unspecified
15	Joint Plane	59.7	349	1424163.018	740893.339	2560.973	0.268	0.734	1424162.698	740893.251	2560.982	1424163.4	740893.454	2560.924	Unspecified	Unspecified
16	Joint Plane	64	343.3	1424162.583	740894.764	2558.792	0.039	0.472	1424162.385	740894.701	2558.796	1424162.829	740894.859	2558.766	Unspecified	Unspecified
17	Joint Plane	79.4	342.8	1424162.562	740894.804	2558.58	0.02	0.329	1424162.654	740894.828	2558.634	1424162.349	740894.734	2558.553	Unspecified	Unspecified
18	Joint Plane	81.6	300.1	1424166.263	740888.887	2565.602	6.388	3.889	1424166.803	740889.365	2567.363	1424165.664	740888.568	2563.731	Unspecified	Unspecified
19	Joint Plane	65.6	195.7	1424170.267	740867.945	2560.363	1.026	2.345	1424171.1	740868.102	2561.17	1424169.387	740867.789	2559.599	Unspecified	Unspecified

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Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	38.3	226.6	1424224.529	740733.344	2554.195	30.593	7.77	1424228.028	740732.195	2555.379	1424221.08	740734.744	2553.011	Unspecified	Unspecified
1	Joint Plane	70.7	60	1424226.944	740732.83	2558.577	21.68	6.051	1424224.952	740734.754	2559.854	1424228.535	740730.373	2557.713	Unspecified	Unspecified
2	Joint Plane	35.9	221.1	1424224.32	740736.343	2564.058	1.473	1.842	1424225.014	740735.872	2564.128	1424223.601	740737.053	2564.114	Unspecified	Unspecified
3	Joint Plane	72.8	57.5	1424230.992	740733.606	2569.066	1.018	2.442	1424231.665	740732.54	2569.1	1424230.334	740734.586	2569.027	Unspecified	Unspecified
4	Joint Plane	79.3	152.6	1424235.971	740726.287	2572.914	0.624	1.469	1424236.327	740726.558	2573.465	1424235.569	740725.973	2572.351	Unspecified	Unspecified
5	Joint Plane	69.4	131.9	1424233.479	740727.297	2567.228	0.013	0.194	1424233.406	740727.232	2567.259	1424233.544	740727.341	2567.179	Unspecified	Unspecified
6	Joint Plane	82.9	328.4	1424233.704	740727.542	2567.821	0.163	0.69	1424233.972	740727.612	2568.037	1424233.532	740727.433	2567.538	Unspecified	Unspecified
7	Joint Plane	81.2	134.5	1424233.51	740727.391	2567.459	0.027	0.252	1424233.429	740727.327	2567.53	1424233.578	740727.441	2567.361	Unspecified	Unspecified
8	Fault	80.7	333.8	1424187.113	740802.384	2549.994	1.18	2.9	1424188.132	740802.728	2550.854	1424185.935	740801.957	2549.126	Unspecified	Unspecified
9	Joint Plane	30.6	133	1424195.534	740815.628	2572.078	4.649	4.177	1424194.222	740814.378	2572.151	1424197.234	740817.272	2572.091	Unspecified	Unspecified
10	Joint Plane	46	125.7	1424194.27	740815.645	2572.65	0.013	0.352	1424194.167	740815.505	2572.653	1424194.385	740815.782	2572.636	Unspecified	Unspecified
11	Joint Plane	16.2	91.5	1424194.987	740811.092	2572.785	0.35	0.959	1424194.801	740810.764	2572.822	1424195.474	740811.426	2572.653	Unspecified	Unspecified

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Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	60	82.6	1424235.912	740681.28	2558.276	6.68	4.667	1424235.5	740683.696	2558.563	1424236.925	740679.489	2557.132	Unspecified	Unspecified
1	Joint Plane	64.2	237.5	1424238.781	740681.358	2564.36	1.073	1.648	1424238.512	740682.027	2564.651	1424239.194	740680.623	2564.122	Unspecified	Unspecified
2	Joint Plane	69.6	276.3	1424241.713	740683.529	2569.534	2.58	3.007	1424242.199	740684.213	2570.779	1424240.983	740683.271	2568.195	Unspecified	Unspecified
3	Joint Plane	86.8	315.6	1424247.88	740696.652	2580.776	3.276	4.32	1424248.773	740697.26	2582.685	1424247.133	740695.938	2578.914	Unspecified	Unspecified
4	Joint Plane	87.8	314.5	1424245.459	740699.648	2577.258	0.823	1.82	1424245.756	740699.945	2577.932	1424244.922	740699.196	2576.499	Unspecified	Unspecified
5	Joint Plane	59.4	229	1424246.934	740698.54	2580.096	4.645	3.493	1424246.818	740699.799	2581.316	1424247.158	740697.256	2578.945	Unspecified	Unspecified
6	Joint Plane	66.9	307.5	1424249.279	740689.242	2581.307	6.052	6.131	1424251.483	740690.706	2583.138	1424247.417	740688.144	2579.331	Unspecified	Unspecified
7	Joint Plane	57.3	229.6	1424246.216	740680.059	2572.312	13.648	5.507	1424248.223	740679.306	2573.907	1424244.068	740680.907	2570.668	Unspecified	Unspecified
8	Joint Plane	86.4	139.3	1424254.236	740687.199	2590.392	2.273	2.331	1424254.626	740687.655	2591.382	1424253.352	740686.581	2589.753	Unspecified	Unspecified
9	Joint Plane	80.7	316.5	1424255.157	740687.763	2594.719	1.756	2.573	1424256.065	740688.324	2595.682	1424254.575	740687.351	2593.822	Unspecified	Unspecified
10	Joint Plane	85.8	152	1424255.135	740669.29	2583.968	0.982	1.521	1424255.179	740669.38	2584.712	1424255	740669.18	2583.215	Unspecified	Unspecified
11	Joint Plane	83.6	332	1424253.242	740658.021	2568.754	5.493	4.019	1424254.107	740658.253	2570.581	1424252.461	740657.796	2566.943	Unspecified	Unspecified
12	Joint Plane	85.8	154.9	1424253.389	740654.137	2566.508	3.979	3.054	1424252.403	740653.781	2567.64	1424254.956	740654.717	2566.251	Unspecified	Unspecified
13	Joint Plane	88.4	155.7	1424252.809	740647.819	2559.604	1.394	2.185	1424253.318	740648.064	2560.539	1424252.419	740647.656	2558.59	Unspecified	Unspecified
14	Joint Plane	84.4	158.8	1424259.317	740642.812	2570.683	1.128	1.757	1424259.706	740643.072	2571.43	1424259.01	740642.586	2569.892	Unspecified	Unspecified
15	Joint Plane	30.7	357.5	1424255.736	740672.034	2595.085	2.506	3.25	1424256.822	740671.031	2595.657	1424254.242	740672.717	2594.626	Unspecified	Unspecified
16	Joint Plane	58.5	241.2	1424248.93	740672.26	2568.328	20.918	6.617	1424249.175	740674.676	2570.581	1424248.643	740669.831	2566.104	Unspecified	Unspecified
17	Joint Plane	61.2	234.7	1424249.512	740658.768	2557.703	27.422	7.339	1424249.282	740661.356	2560.243	1424249.328	740656.072	2555.15	Unspecified	Unspecified
18	Joint Plane	76.3	66	1424266.03	740654.445	2598.021	4.675	3.188	1424265.342	740655.395	2599.077	1424266.723	740653.578	2596.85	Unspecified	Unspecified
19	Joint Plane	59.9	232.5	1424240.653	740667.91	2552.97	31.446	8.868	1424243.468	740668.19	2556.755	1424237.757	740668.782	2549.997	Unspecified	Unspecified
20	Joint Plane	86.4	153	1424257.413	740658.026	2575.548	1.049	1.674	1424256.661	740657.671	2575.814	1424258.116	740658.302	2575.278	Unspecified	Unspecified
21	Joint Plane	85.7	150.8	1424257.104	740670.496	2585.671	0.684	1.61	1424257.674	740670.897	2586.246	1424256.879	740670.318	2584.971	Unspecified	Unspecified
22	Joint Plane	80.7	153.2	1424256.864	740670.297	2584.669	0.017	0.446	1424256.996	740670.359	2584.64	1424256.601	740670.154	2584.611	Unspecified	Unspecified
23	Joint Plane	81.9	154.8	1424257.525	740667.314	2600.779	4.714	4.389	1424258.42	740667.957	2602.486	1424256.396	740666.469	2598.887	Unspecified	Unspecified
24	Joint Plane	58	230.7	1424249.954	740708.338	2588.128	10.488	5.013	1424250.63	740709.574	2590.12	1424249.081	740707.264	2585.95	Unspecified	Unspecified
25	Joint Plane	72.9	306	1424248.407	740704.515	2584.911	2.919	5.732	1424249.91	740705.455	2587.008	1424246.673	740703.489	2582.706	Unspecified	Unspecified
26	Joint Plane	48.6	67.4	1424258.35	740669.416	2591.678	1.016	1.784	1424257.844	740670.038	2591.886	1424258.819	740668.552	2591.724	Unspecified	Unspecified
27	Joint Plane	88.1	75.2	1424262.366	740659.737	2604.102	1.039	1.529	1424262.578	740659.533	2604.877	1424262.23	740660.404	2603.669	Unspecified	Unspecified
28	Joint Plane	55.5	229.7	1424235.205	740679.981	2554.024	10.351	4.739	1424235.78	740681.32	2555.97	1424234.994	740678.373	2552.343	Unspecified	Unspecified

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Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	64.9	70.9	1424273.918	740611.439	2564.545	15.158	9.88	1424271.519	740615.169	2566.623	1424276.098	740607.421	2562.545	Unspecified	Unspecified
1	Joint Plane	62.8	227.8	1424275.4	740609.37	2566.336	11.956	5.07	1424276.178	740610.348	2568.664	1424275.78	740607.453	2564.521	Unspecified	Unspecified
2	Joint Plane	77	62	1424270.305	740619.504	2578.066	18.113	5.97	1424270.868	740617.48	2580.332	1424270.169	740621.132	2575.661	Unspecified	Unspecified
3	Joint Plane	51.7	19.2	1424304.623	740575.971	2599.295	0.692	2.599	1424305.651	740575.348	2599.831	1424303.752	740576.622	2598.595	Unspecified	Unspecified
4	Joint Plane	36.9	14.9	1424302.178	740576.863	2599.342	4.683	4.692	1424303.807	740575.392	2600.244	1424300.771	740578.432	2598.357	Unspecified	Unspecified
5	Joint Plane	35.5	218.1	1424294.242	740588.682	2586.215	13.977	7.303	1424291.52	740591.045	2586.32	1424297.029	740586.258	2586.07	Unspecified	Unspecified
6	Joint Plane	82.5	63.5	1424292.932	740588.407	2582.375	24.606	6.608	1424292.081	740589.322	2585.273	1424294.2	740586.735	2579.574	Unspecified	Unspecified
7	Joint Plane	46.8	240.8	1424270.893	740620	2582.255	10.683	5.207	1424271.674	740622.441	2583.592	1424270.763	740617.943	2581.132	Unspecified	Unspecified
8	Joint Plane	63.9	230.1	1424273.047	740613.568	2568.325	16.7	5.98	1424275.53	740611.857	2569.696	1424271.198	740615.469	2567.709	Unspecified	Unspecified
9	Joint Plane	68.8	232.5	1424268.79	740619.253	2569.157	16.573	6.355	1424267.917	740621.715	2571.167	1424270.778	740616.564	2568.786	Unspecified	Unspecified

10	Joint Plane	81.4	267	1424285.219	740593.078	2563.793	6.948	3.973	1424287.198	740593.88	2564.604	1424283.896	740592.395	2562.966	Unspecified	Unspecified
11	Joint Plane	78.9	68.6	1424291.604	740581.653	2562.017	6.906	4.165	1424290.757	740583.012	2563.507	1424292.446	740579.487	2562.068	Unspecified	Unspecified
12	Joint Plane	67.3	218.3	1424274.548	740629.693	2588.722	5.879	5.204	1424275.568	740630.036	2591.156	1424274.515	740628.412	2586.326	Unspecified	Unspecified
13	Joint Plane	53.7	221.2	1424280.57	740608.122	2569.911	24.849	7.649	1424280.156	740610.912	2572.521	1424280.095	740605.636	2566.984	Unspecified	Unspecified
14	Joint Plane	89.8	319.4	1424292.49	740578.964	2558.897	3.025	3.871	1424293.281	740579.619	2560.521	1424291.829	740578.422	2557.138	Unspecified	Unspecified
15	Joint Plane	32.7	244.3	1424291.147	740576.653	2555.669	2.602	2.557	1424292.199	740575.843	2556.073	1424290.126	740577.063	2555.205	Unspecified	Unspecified
16	Joint Plane	82.8	315.8	1424294.173	740574.631	2558.263	1.989	3.121	1424294.481	740574.724	2559.754	1424294.065	740574.635	2556.662	Unspecified	Unspecified
17	Joint Plane	79.9	228.9	1424293.13	740570.01	2554.675	9.846	5.151	1424294.394	740569.001	2556.63	1424291.288	740571.617	2553.46	Unspecified	Unspecified
18	Joint Plane	85.6	13.6	1424293.557	740575.673	2558.611	4.181	3.509	1424294.564	740575.319	2559.946	1424292.577	740575.925	2557.118	Unspecified	Unspecified

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Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	59.8	35.9	1424320.89	740564.285	2601.262	22.313	10.959	1424316.404	740567.009	2601.909	1424325.981	740561.81	2600.74	Unspecified	Unspecified
1	Joint Plane	80.6	262.3	1424327.664	740560.743	2603.444	6.228	4.897	1424328.241	740561.756	2605.824	1424327.108	740561.237	2601.089	Unspecified	Unspecified
2	Joint Plane	88.8	163.9	1424326.087	740561.445	2602.874	2.837	3.13	1424326.851	740561.671	2604.421	1424325.295	740561.17	2601.752	Unspecified	Unspecified
3	Joint Plane	75	169.4	1424331.773	740558.345	2603.574	0.129	1.236	1424332.144	740558.483	2603.848	1424331.181	740558.113	2603.168	Unspecified	Unspecified
4	Joint Plane	80.6	166	1424332.821	740558.769	2604.59	0.627	2.057	1424333.489	740559.071	2605.289	1424332.144	740558.483	2603.848	Unspecified	Unspecified
5	Joint Plane	69.4	22	1424336.494	740557.605	2605.937	2.717	3.012	1424337.935	740557.229	2605.799	1424335.101	740558.176	2605.417	Unspecified	Unspecified
6	Joint Plane	47	29.5	1424329.794	740559.246	2601.493	5.795	3.928	1424328.126	740559.136	2602.184	1424331.838	740558.876	2600.929	Unspecified	Unspecified
7	Joint Plane	65.4	60.3	1424329.954	740559.697	2597.009	2.489	2.973	1424329.116	740560.409	2597.874	1424330.953	740558.661	2596.322	Unspecified	Unspecified
8	Joint Plane	48.7	221.7	1424323.475	740555.885	2588.274	21.667	9.455	1424326.839	740557.338	2591.798	1424320.575	740554.67	2585.237	Unspecified	Unspecified
9	Joint Plane	51.7	223.8	1424339.301	740547.212	2592.832	22.536	6.769	1424340.228	740549.512	2595.362	1424338.482	740545.354	2590.315	Unspecified	Unspecified
10	Joint Plane	51.6	220.4	1424330.478	740551.617	2590.201	9.026	5.047	1424331.803	740552.819	2592.362	1424329.848	740550.232	2588.494	Unspecified	Unspecified
11	Joint Plane	57.1	56.3	1424329.374	740551.366	2587.878	2.609	2.751	1424330.065	740550.205	2588.189	1424328.765	740552.565	2587.636	Unspecified	Unspecified
12	Joint Plane	69.7	63.6	1424334.527	740548	2588.242	3.881	2.903	1424333.797	740548.53	2589.348	1424335.315	740547.176	2587.277	Unspecified	Unspecified
13	Joint Plane	46	216.8	1424333.538	740544.73	2580.03	56.139	11.478	1424333.396	740549.386	2583.584	1424333.661	740540.403	2576.443	Unspecified	Unspecified
14	Joint Plane	78.1	273.6	1424334.679	740538.169	2577.024	1.719	2.15	1424335.032	740538.565	2577.99	1424334.432	740538.152	2575.967	Unspecified	Unspecified
15	Joint Plane	82.2	71.6	1424333.77	740537.783	2573.039	5.47	3.987	1424333.119	740539.252	2574.336	1424334.389	740536.437	2571.816	Unspecified	Unspecified
16	Joint Plane	89.9	75.4	1424330.983	740544.262	2576.599	2.941	2.851	1424330.687	740544.918	2577.843	1424331.066	740543.624	2575.331	Unspecified	Unspecified
17	Joint Plane	71.6	293.2	1424333.474	740535.14	2570.575	2.416	2.948	1424334.105	740535.215	2571.931	1424332.946	740535.095	2569.223	Unspecified	Unspecified
18	Joint Plane	46.5	211.5	1424332.159	740537.379	2570.399	9.007	4.35	1424332.577	740539.019	2571.926	1424332.036	740535.864	2568.982	Unspecified	Unspecified
19	Joint Plane	69.9	296.9	1424340.143	740515.559	2572.649	12.162	4.726	1424341.231	740515.729	2574.761	1424339.17	740515.478	2570.516	Unspecified	Unspecified
20	Joint Plane	84.4	286.8	1424342.452	740514.43	2578.272	2.183	2.991	1424343.032	740515.146	2579.504	1424342.163	740514.095	2576.843	Unspecified	Unspecified
21	Joint Plane	49.3	217.5	1424338.021	740515.659	2557.902	14.692	6.365	1424337.839	740518.104	2559.974	1424337.868	740513.415	2555.669	Unspecified	Unspecified
22	Joint Plane	89.6	57.3	1424337.884	740513.391	2555.642	0.005	0.099	1424337.868	740513.415	2555.669	1424337.907	740513.355	2555.601	Unspecified	Unspecified
23	Joint Plane	47.1	231.5	1424337.849	740518.147	2560.019	0.009	0.158	1424337.889	740518.11	2560.046	1424337.759	740518.163	2559.973	Unspecified	Unspecified
24	Joint Plane	76	71.8	1424335.936	740516.421	2555.997	3.305	3.436	1424335.302	740517.997	2556.178	1424336.656	740514.867	2555.759	Unspecified	Unspecified
25	Joint Plane	77.7	271.7	1424336.875	740513.848	2554.068	0.416	1.476	1424337.147	740514.013	2554.749	1424336.74	740513.733	2553.358	Unspecified	Unspecified
26	Joint Plane	65	202.3	1424337.074	740512.942	2553.951	1.108	1.51	1424336.735	740513.322	2554.523	1424337.202	740512.617	2553.273	Unspecified	Unspecified
27	Joint Plane	52.3	221	1424325.982	740537.755	2566.288	25.463	6.981	1424328.732	740538.238	2568.667	1424323.083	740538.238	2564.565	Unspecified	Unspecified
28	Joint Plane	77.1	65.5	1424299.072	740559.176	2576.195	15.814	6.836	1424297.911	740560.159	2579.222	1424300.383	740558.139	2573.178	Unspecified	Unspecified
29	Joint Plane	73.3	213.1	1424307.46	740553.379	2578.599	10.989	4.632	1424306.219	740554.589	2580.266	1424308.754	740552.118	2577.28	Unspecified	Unspecified
30	Joint Plane	45.1	212.4	1424304.879	740557.021	2582.545	10.844	4.744	1424303.311	740558.712	2583.164	1424306.546	740555.413	2582.085	Unspecified	Unspecified
31	Joint Plane	81.8	61.9	1424293.333	740587.199	2582.28	16.284	6.284	1424292.369	740588.386	2585.016	1424294.445	740585.887	2579.638	Unspecified	Unspecified
32	Joint Plane	38.3	227.1	1424292.362	740577.695	2560.682	4.828	3.708	1424291.906	740579.51	2561.142	1424293.47	740576.21	2560.497	Unspecified	Unspecified

33	Joint Plane	51.9	223.2	1424292.5	740581.824	2564.583	8.982	4.524	1424294.391	740580.584	2564.81	1424290.924	740583.485	2564.638	Unspecified	Unspecified

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Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	60.8	283.6	1424348.89	740510.05	2590.692	25.727	8.662	1424350.664	740508.718	2594.367	1424346.894	740511.081	2586.934	Unspecified	Unspecified
1	Joint Plane	78.3	61.9	1424348.539	740506.203	2588.133	5.194	3.723	1424347.948	740507.932	2587.515	1424348.822	740504.405	2586.701	Unspecified	Unspecified
2	Joint Plane	58.8	228.4	1424348.103	740521.318	2605.977	25.348	6.994	1424348.052	740523.766	2608.462	1424347.98	740518.824	2603.514	Unspecified	Unspecified
3	Joint Plane	47.1	230.6	1424346.013	740501.36	2568.806	18.888	7.559	1424348.599	740501.211	2570.928	1424342.245	740503.203	2567.349	Unspecified	Unspecified
4	Joint Plane	39.8	227.6	1424344.935	740504.635	2570.087	4.955	3.891	1424346.51	740504.071	2570.764	1424343.178	740504.196	2568.76	Unspecified	Unspecified
5	Joint Plane	63.6	46	1424341.671	740509.372	2572.927	14.524	5.745	1424341.166	740512.652	2573.321	1424343.576	740507.488	2572.598	Unspecified	Unspecified
6	Joint Plane	67.1	82.1	1424373.911	740473.079	2583.701	24.431	10.277	1424372.128	740476.882	2586.852	1424375.575	740469.18	2580.985	Unspecified	Unspecified
7	Joint Plane	81.9	69.3	1424376.665	740463.427	2571.785	7.356	4.184	1424376.121	740464.181	2573.612	1424377.213	740462.674	2569.864	Unspecified	Unspecified
8	Joint Plane	50.4	220.8	1424374.048	740473.281	2587.344	10.378	6.18	1424372.553	740475.872	2588.611	1424376.047	740471.077	2586.881	Unspecified	Unspecified
9	Joint Plane	48.7	219.6	1424389.533	740453.225	2577.866	16.728	7.162	1424388.701	740456.354	2579.403	1424391.819	740450.313	2577.148	Unspecified	Unspecified
10	Joint Plane	54.1	186.7	1424359.792	740466.662	2559.498	16.795	6.817	1424359.814	740468.56	2562.285	1424359.738	740464.642	2556.706	Unspecified	Unspecified
11	Joint Plane	72.5	212.3	1424364.956	740460.667	2550.875	16.374	7.302	1424362.06	740462.679	2552.202	1424366.934	740458.602	2548.605	Unspecified	Unspecified
12	Joint Plane	85.6	237	1424372.863	740453.007	2552.665	14.578	5.646	1424374.416	740450.983	2554.551	1424371.279	740455.18	2552.447	Unspecified	Unspecified
13	Joint Plane	83.8	33.7	1424371.787	740455.815	2556.548	7.42	6.602	1424373.59	740454.561	2558.693	1424369.91	740457.165	2553.869	Unspecified	Unspecified
14	Joint Plane	77.4	281	1424352.228	740469.101	2550.252	14.1	5.478	1424353.077	740470.475	2552.58	1424351.405	740468.053	2547.96	Unspecified	Unspecified
15	Joint Plane	47.6	212.2	1424342.893	740487.97	2554.19	33.336	8.853	1424345.974	740488.507	2556.362	1424338.077	740488.95	2552.383	Unspecified	Unspecified
16	Joint Plane	55.5	57	1424363.726	740471.515	2568.149	4.285	2.744	1424363.666	740470.574	2568.916	1424363.839	740472.754	2567.259	Unspecified	Unspecified
17	Joint Plane	54.3	52.9	1424362.403	740473.024	2568.278	1.406	2.521	1424361.484	740473.052	2569.128	1424363.368	740472.938	2567.456	Unspecified	Unspecified
18	Joint Plane	43.7	206.7	1424360.308	740475.649	2572.731	6.589	4.425	1424361.429	740477.094	2574.361	1424359.565	740474.323	2571.459	Unspecified	Unspecified
19	Joint Plane	48.1	215.9	1424337.143	740516.735	2558.817	27.74	8.431	1424338.477	740519.369	2561.884	1424336.935	740513.636	2555.897	Unspecified	Unspecified
20	Joint Plane	71.5	69.9	1424338.023	740520.742	2564.45	4.404	3.45	1424338.585	740519.164	2564.66	1424337.455	740522.421	2564.505	Unspecified	Unspecified
21	Joint Plane	30	93.1	1424337.579	740508.511	2562.044	2.123	2.94	1424337.423	740509.967	2562.204	1424337.719	740507.054	2561.934	Unspecified	Unspecified
22	Joint Plane	86.4	293.7	1424338.916	740505.412	2558.298	7.695	3.978	1424339.626	740506.905	2559.43	1424338.076	740503.464	2558.173	Unspecified	Unspecified
23	Joint Plane	67.1	71.4	1424339.71	740510.056	2559.569	4.74	2.857	1424339.067	740510.257	2560.771	1424340.432	740509.311	2558.445	Unspecified	Unspecified
24	Joint Plane	61.9	72.3	1424334.258	740518.224	2557.086	1.515	2.529	1424334.701	740516.978	2557.003	1424334.017	740519.412	2556.944	Unspecified	Unspecified
25	Joint Plane	58.8	265.5	1424335.045	740495.903	2552.75	5.509	3.989	1424335.256	740497.823	2553.282	1424334.318	740494.307	2551.647	Unspecified	Unspecified
26	Joint Plane	81.1	273	1424358.793	740477.111	2571.268	6.86	3.783	1424359.189	740477.708	2573.162	1424358.669	740478.417	2569.483	Unspecified	Unspecified
27	Joint Plane	79.4	68.2	1424335.76	740491.007	2550.048	6.612	4.702	1424335.057	740491.603	2552.176	1424336.456	740490.484	2547.828	Unspecified	Unspecified
28	Joint Plane	44.6	211.2	1424374.998	740470.174	2578.991	8.013	5.5	1424373.87	740472.257	2580.264	1424376.486	740468.042	2577.892	Unspecified	Unspecified
29	Joint Plane	42.4	212.8	1424367.967	740463.493	2564.078	4.568	3.335	1424366.683	740464.562	2564.244	1424369.218	740462.462	2563.716	Unspecified	Unspecified
30	Joint Plane	68.9	64.3	1424358.452	740487.955	2576.13	4.914	3.934	1424357.511	740489.651	2576.457	1424359.356	740486.205	2576.02	Unspecified	Unspecified

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Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	45.1	210.1	1424414.193	740413.187	2565.062	68.152	11.082	1424417.254	740416.492	2569.073	1424411.609	740410.555	2561.611	Unspecified	Unspecified
1	Joint Plane	46.6	214.9	1424414.866	740419.624	2570.899	16.601	7.461	1424418.177	740417.989	2571.483	1424411.706	740421.665	2570.963	Unspecified	Unspecified
2	Joint Plane	72.5	62.7	1424414.658	740424.889	2576.096	4.874	3.779	1424413.61	740425.788	2577.43	1424415.702	740423.765	2575.02	Unspecified	Unspecified
3	Joint Plane	89.3	56.5	1424409.822	740423.429	2567.469	42.735	10.084	1424412.422	740419.701	2568.903	1424407.066	740428.114	2567.418	Unspecified	Unspecified
4	Joint Plane	82.5	65.5	1424405.356	740431.764	2572.784	47.954	11.869	1424402.717	740436.964	2574.75	1424407.526	740426.62	2571.472	Unspecified	Unspecified
5	Joint Plane	48.1	211.2	1424406.362	740424.028	2561.985	32.573	10.373	1424406.29	740428.087	2565.709	1424406.066	740420.617	2558.516	Unspecified	Unspecified

6	Joint Plane	89.3	241.8	1424403.73	740423.855	2558.87	5.954	4.683	1424404.938	740421.522	2558.199	1424402.721	740425.646	2558.121	Unspecified	Unspecified
7	Joint Plane	49.2	213.5	1424395.593	740442.74	2572.82	23.504	9.812	1424391.785	740445.613	2573.145	1424399.516	740439.628	2572.314	Unspecified	Unspecified
8	Joint Plane	86.4	61.6	1424404.525	740420.959	2554.64	15.752	5.878	1424405.717	740418.727	2556.237	1424403.104	740423.782	2554.762	Unspecified	Unspecified
9	Joint Plane	48.1	211.5	1424402.784	740428.821	2564.44	11.606	5.142	1424401.541	740430.686	2565.511	1424403.399	740426.71	2562.831	Unspecified	Unspecified
10	Joint Plane	73.2	304.2	1424409.161	740418.158	2562.185	6.875	4.946	1424409.921	740418.142	2564.455	1424408.163	740418.413	2559.839	Unspecified	Unspecified
11	Joint Plane	50.1	293.6	1424408.102	740418.407	2559.778	0.021	0.218	1424408.133	740418.496	2559.773	1424408.03	740418.306	2559.752	Unspecified	Unspecified
12	Joint Plane	68.5	275.2	1424422.305	740397.917	2562.266	3.716	2.794	1424422.916	740398.909	2563.284	1424421.683	740396.97	2561.696	Unspecified	Unspecified
13	Joint Plane	82.6	287.2	1424423.142	740400.465	2560.918	9.439	4.684	1424423.883	740402.078	2562.13	1424421.959	740398.934	2559.239	Unspecified	Unspecified
14	Joint Plane	82	287.8	1424418.616	740395.238	2551.7	2.35	2.214	1424418.917	740395.021	2552.805	1424418.638	740395.252	2550.621	Unspecified	Unspecified
15	Joint Plane	51.4	246.9	1424418.244	740393.861	2552.516	1.327	2.128	1424418.756	740394.388	2553.272	1424417.662	740393.487	2551.685	Unspecified	Unspecified
16	Joint Plane	52.8	212.1	1424393.553	740435.213	2552.154	27.979	9.51	1424393.663	740438.442	2555.691	1424392.535	740432.409	2548.428	Unspecified	Unspecified
17	Joint Plane	51.5	215.3	1424396.396	740431.8	2550.38	10.918	5.163	1424398.615	740430.193	2550.406	1424394.194	740432.781	2549.763	Unspecified	Unspecified
18	Joint Plane	48.4	215.1	1424390.507	740447.519	2565.045	7.405	5.772	1424389.562	740449.813	2566.463	1424392.515	740445.334	2564.333	Unspecified	Unspecified
19	Joint Plane	77	63.5	1424390.645	740447.937	2570.637	14.073	5.602	1424389.875	740447.964	2573.252	1424391.821	740446.763	2568.138	Unspecified	Unspecified

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Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	51.6	37.7	1424473.513	740357.502	2576.409	3.781	3.865	1424474.527	740356.249	2577.107	1424472.831	740359.268	2575.389	Unspecified	Unspecified
1	Joint Plane	65.3	76.6	1424471.926	740360.096	2576.729	9.087	4.301	1424471.207	740361.785	2577.579	1424472.252	740357.637	2577.131	Unspecified	Unspecified
2	Joint Plane	70.4	9.5	1424459.631	740359.484	2566.227	11.68	8.928	1424463.744	740358.654	2567.064	1424455.446	740360.706	2564.485	Unspecified	Unspecified
3	Joint Plane	46.9	207.8	1424459.949	740356.937	2563.374	15.093	7.516	1424463.256	740355.343	2563.589	1424456.316	740358.169	2563.007	Unspecified	Unspecified
4	Joint Plane	76.5	71.9	1424441.972	740360.225	2556.01	3.341	2.502	1424441.572	740361.154	2556.389	1424442.28	740358.829	2555.797	Unspecified	Unspecified
5	Joint Plane	52.8	208.4	1424442.962	740359.439	2557.325	3.184	2.676	1424444.204	740359.628	2558.231	1424442.518	740358.789	2556.33	Unspecified	Unspecified
6	Joint Plane	71.8	191.7	1424475.11	740342.67	2566.271	1.006	1.95	1424476.006	740342.434	2566.151	1424474.097	740342.642	2565.811	Unspecified	Unspecified
7	Joint Plane	74.8	3.8	1424473.794	740343.399	2561.264	0.307	1.367	1424474.399	740343.311	2561.293	1424473.05	740343.311	2561.077	Unspecified	Unspecified
8	Joint Plane	87.6	59.6	1424472.804	740345.044	2564.672	4.784	3.605	1424472.267	740345.876	2566.144	1424473.343	740344.239	2563.117	Unspecified	Unspecified
9	Joint Plane	89.5	68.9	1424471.723	740347.794	2564.971	2.762	2.293	1424471.672	740347.992	2566.06	1424471.9	740347.388	2563.859	Unspecified	Unspecified
10	Joint Plane	51.7	215.1	1424488.518	740340.371	2584.546	4.52	3.072	1424488.685	740341.391	2585.631	1424487.641	740339.528	2583.423	Unspecified	Unspecified
11	Joint Plane	79.5	65.8	1424489.804	740335.67	2578.079	1.381	1.807	1424489.472	740336.147	2578.772	1424490.12	740335.347	2577.287	Unspecified	Unspecified
12	Joint Plane	54.5	209.6	1424483.397	740345.702	2581.445	0.655	1.37	1424484.141	740345.484	2581.532	1424482.89	740346.036	2581.458	Unspecified	Unspecified
13	Joint Plane	46.4	207.8	1424490.33	740336.647	2582.301	2.303	2.59	1424490.47	740337.325	2583.076	1424489.38	740335.9	2581.208	Unspecified	Unspecified
14	Joint Plane	45	202.2	1424488.791	740336.761	2581.683	0.022	0.406	1424488.967	740336.766	2581.758	1424488.6	740336.733	2581.588	Unspecified	Unspecified
15	Joint Plane	42.3	201.8	1424488.844	740337.439	2582.222	1.837	2.057	1424489.755	740337.428	2582.596	1424487.789	740337.789	2582.113	Unspecified	Unspecified
16	Joint Plane	56.2	220	1424473.121	740356.935	2577.594	0.659	1.785	1424473.908	740356.57	2577.608	1424472.336	740357.406	2577.482	Unspecified	Unspecified
17	Joint Plane	70.1	237.9	1424473.811	740356.416	2577.479	0.007	0.144	1424473.854	740356.372	2577.515	1424473.769	740356.449	2577.429	Unspecified	Unspecified
18	Joint Plane	62	5	1424480.847	740337.693	2565.345	1.824	2.115	1424481.315	740337.116	2566.111	1424480.007	740338.001	2564.705	Unspecified	Unspecified
19	Fault	87.2	307.8	1424474.127	740354.941	2575.956	2.809	2.954	1424475.168	740356.173	2575.966	1424473.358	740353.844	2575.801	Unspecified	Unspecified
20	Joint Plane	66.4	70.9	1424477.721	740339.763	2564.72	7.271	4.176	1424476.926	740339.466	2566.492	1424478.487	740340.392	2562.732	Unspecified	Unspecified

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Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	75.4	64.7	1424506.991	740292.359	2567.556	96.917	15.925	1424503.739	740296.151	2573.336	1424510.499	740287.785	2561.592	Unspecified	Unspecified
1	Joint Plane	77.2	62.6	1424502.383	740299.763	2571.667	9.973	4.817	1424503.104	740297.74	2572.997	1424501.649	740301.77	2570.797	Unspecified	Unspecified
2	Joint Plane	68.8	214.5	1424522.474	740273.294	2569.787	38.784	8.641	1424525.931	740272.51	2572.299	1424519.446	740273.998	2566.784	Unspecified	Unspecified
3	Joint Plane	74.9	218.5	1424520.13	740271.784	2561.916	23.162	7.771	1424518.538	740273.866	2564.816	1424521.885	740269.485	2559.338	Unspecified	Unspecified
4	Joint Plane	71.5	218	1424527.322	740269.639	2569.675	6.681	3.566	1424528.444	740269.199	2570.699	1424525.919	740270.064	2568.334	Unspecified	Unspecified
5	Joint Plane	78.9	63	1424507.271	740286.892	2553.254	21.042	8.452	1424505.398	740290.437	2554.08	1424509.347	740283.127	2552.531	Unspecified	Unspecified
6	Joint Plane	54.1	198.2	1424505.224	740289.712	2557.028	0.42	1.175	1424504.932	740290.081	2557.36	1424505.564	740289.35	2556.692	Unspecified	Unspecified
7	Joint Plane	48.2	258.6	1424506.404	740289.204	2576.009	0.896	1.562	1424506.846	740288.722	2576.445	1424506.045	740289.844	2575.71	Unspecified	Unspecified
8	Joint Plane	61.3	212.5	1424501.454	740302.118	2581.95	5.389	4.484	1424503.127	740302.184	2583.513	1424499.898	740302.186	2580.402	Unspecified	Unspecified
9	Joint Plane	50.1	250.9	1424506.657	740298.395	2581.755	1.888	2.099	1424507.401	740297.784	2582.244	1424506.244	740299.441	2581.677	Unspecified	Unspecified
10	Joint Plane	46.7	237.5	1424503.383	740297.506	2577.729	0.685	1.861	1424503.626	740298.223	2578.222	1424503.292	740296.654	2577.279	Unspecified	Unspecified
11	Joint Plane	50.2	260.6	1424504.384	740302.601	2587.142	3.5	3.208	1424505.275	740302.441	2588.196	1424503.125	740302.14	2585.834	Unspecified	Unspecified
12	Joint Plane	54.6	241.3	1424508.126	740303.499	2595.179	2.101	2.559	1424508.444	740304.361	2596.029	1424507.69	740302.704	2594.23	Unspecified	Unspecified
13	Joint Plane	50.5	63.7	1424509.951	740300.373	2592.674	1.733	2.25	1424510.31	740299.328	2592.85	1424509.622	740301.452	2592.561	Unspecified	Unspecified
14	Joint Plane	52.3	226.9	1424509.034	740301.453	2594.919	1.403	2.057	1424509.225	740302.188	2595.63	1424508.87	740300.763	2594.189	Unspecified	Unspecified
15	Joint Plane	49.6	212.9	1424505.692	740306.141	2595.685	1.052	1.855	1424505.993	740306.685	2596.491	1424505.837	740305.42	2595.143	Unspecified	Unspecified
16	Joint Plane	43.3	232.1	1424505.807	740305.339	2595.077	0.018	0.257	1424505.837	740305.42	2595.143	1424505.771	740305.229	2594.984	Unspecified	Unspecified
17	Joint Plane	60.7	272.8	1424509.762	740296.202	2584.891	13.439	5.687	1424510.69	740298.811	2585.764	1424508.594	740294.223	2583.135	Unspecified	Unspecified
18	Joint Plane	80.2	161.1	1424509.706	740300.802	2587.562	2.777	2.9	1424508.947	740300.807	2588.721	1424510.178	740300.758	2586.095	Unspecified	Unspecified
19	Joint Plane	89	325	1424508.789	740300.687	2588.702	0.028	0.419	1424508.94	740300.781	2588.798	1424508.642	740300.576	2588.586	Unspecified	Unspecified
20	Joint Plane	73.4	65.3	1424511.601	740299.706	2590.087	9.594	5.043	1424511.589	740298.294	2592.163	1424511.744	740301.015	2587.92	Unspecified	Unspecified
21	Joint Plane	77.5	161.6	1424509.033	740301.409	2591.086	2.892	2.663	1424507.814	740300.988	2591.683	1424509.952	740301.5	2590.182	Unspecified	Unspecified
22	Joint Plane	81.2	155.3	1424509.933	740301.455	2590.045	0.02	0.349	1424510.075	740301.537	2590.137	1424509.823	740301.389	2589.948	Unspecified	Unspecified
23	Joint Plane	79.9	66.7	1424506.147	740298.051	2580.367	0.983	2.215	1424506.425	740297.117	2580.89	1424505.951	740298.892	2579.654	Unspecified	Unspecified
24	Joint Plane	88.5	57.3	1424500.195	740301.371	2578.658	5.15	3.155	1424501.104	740301.101	2580.101	1424499.771	740302.333	2577.52	Unspecified	Unspecified
25	Joint Plane	85.2	66.4	1424504.21	740301.107	2583.665	0.961	1.408	1424504.001	740301.536	2584.152	1424504.418	740300.66	2583.131	Unspecified	Unspecified
26	Joint Plane	89.3	145.2	1424502.728	740301.372	2580.921	1.416	2.098	1424503.628	740302.078	2580.833	1424502.043	740300.803	2580.319	Unspecified	Unspecified
27	Joint Plane	62.3	289.7	1424517.339	740278.109	2568.024	3.514	3.326	1424518.071	740277.954	2569.395	1424516.401	740278.169	2566.527	Unspecified	Unspecified
28	Joint Plane	54.2	278	1424520.516	740277.855	2573.165	3.539	3.175	1424521.378	740277.447	2574.489	1424519.637	740278.255	2571.96	Unspecified	Unspecified
29	Joint Plane	69.8	284.3	1424525.119	740280.259	2580.653	2.79	2.436	1424525.64	740281.288	2580.972	1424524.665	740279.15	2580.328	Unspecified	Unspecified
30	Joint Plane	72.8	295.1	1424528.862	740278.687	2589.606	3.692	2.817	1424528.619	740277.593	2590.17	1424529.495	740280.177	2589.468	Unspecified	Unspecified
31	Joint Plane	50.8	238.6	1424516.24	740284.568	2572.162	7.834	4.544	1424517.556	740285.18	2573.908	1424514.703	740284.295	2570.484	Unspecified	Unspecified
32	Joint Plane	75.5	277.8	1424520.782	740267.425	2549.349	1.639	2.145	1424521.007	740267.097	2550.422	1424520.585	740267.725	2548.415	Unspecified	Unspecified
33	Joint Plane	78.5	303.3	1424522.134	740268.216	2554.635	0.92	2.483	1424522.354	740268.069	2555.811	1424521.628	740267.971	2553.438	Unspecified	Unspecified
34	Joint Plane	54.8	199.3	1424511.701	740282.391	2553.488	21.421	7.335	1424512.33	740284.505	2556.453	1424511.541	740280.136	2550.614	Unspecified	Unspecified
35	Joint Plane	53.7	195.5	1424507.418	740289.503	2560.33	6.391	3.51	1424509.05	740289.028	2560.404	1424505.615	740289.561	2559.923	Unspecified	Unspecified

41_planes.xls

Description	Classification	Dip	DDN	E	N	Height	Area	Max Chord	Top E	Top N	Top H	Bot E	Bot N	Bot H	TTN	BTN
0	Joint Plane	41.2	222.2	1424568.24	740243.664	2584.082	4.187	3.303	1424567.858	740244.958	2584.663	1424568.528	740242.048	2583.252	Unspecified	Unspecified
1	Joint Plane	62.6	261.2	1424566.951	740247.06	2585.421	1.445	2.96	1424567.322	740247.975	2586.491	1424566.282	740246.224	2584.342	Unspecified	Unspecified
2	Joint Plane	41.8	221	1424564.659	740250.556	2587.161	4.816	3.144	1424565.872	740251.003	2588.179	1424564.017	740249.508	2586.127	Unspecified	Unspecified
3	Joint Plane	68.6	205	1424572.821	740240.96	2581.779	1.414	2.769	1424573.092	740241.478	2583.039	1424572.537	740240.548	2580.491	Unspecified	Unspecified
4	Joint Plane	50.9	219.4	1424567.894	740241.522	2567.328	10.36	5.113	1424569.176	740242.333	2569.16	1424565.607	740241.361	2565.63	Unspecified	Unspecified
5	Joint Plane	70	72.7	1424572.75	740239.845	2569.075	3.685	2.839	1424573.056	740238.548	2569.548	1424572.357	740241.233	2568.948	Unspecified	Unspecified
6	Joint Plane	47.8	224.3	1424573.068	740239.616	2570.87	1.314	2.572	1424573.285	740240.615	2571.688	1424573.118	740238.628	2570.063	Unspecified	Unspecified
7	Joint Plane	46.2	223.3	1424574.97	740237.583	2570.765	6.363	4.209	1424575.741	740238.96	2572.197	1424574.016	740236.444	2569.296	Unspecified	Unspecified
8	Joint Plane	45.5	222.9	1424576.548	740235.116	2570.06	10.205	5.373	1424576.912	740237.156	2571.769	1424575.349	740233.512	2568.143	Unspecified	Unspecified
9	Joint Plane	69.9	66.6	1424580.397	740237.025	2575.925	4.266	3.033	1424579.745	740237.284	2577.338	1424580.865	740236.976	2574.537	Unspecified	Unspecified
10	Joint Plane	75.7	72.3	1424554.001	740257.431	2576.592	10.67	6.755	1424552.989	740257.711	2579.748	1424555.006	740257.25	2573.318	Unspecified	Unspecified
11	Joint Plane	75	72.5	1424553.055	740255.619	2581.539	6.319	3.478	1424552.52	740257.697	2581.73	1424553.699	740254.803	2580.203	Unspecified	Unspecified
12	Joint Plane	75	77.2	1424574.03	740238.986	2564.833	4.027	3.127	1424574.264	740237.368	2565.122	1424573.866	740240.386	2564.405	Unspecified	Unspecified
13	Joint Plane	85	342.7	1424568.076	740237.039	2557.889	2.155	2.754	1424568.64	740237.03	2559.063	1424567.351	740236.869	2556.635	Unspecified	Unspecified
14	Joint Plane	82.5	62.4	1424566.374	740237.584	2557.48	2.285	2.583	1424565.972	740238.012	2558.585	1424566.654	740236.967	2556.323	Unspecified	Unspecified
15	Joint Plane	38.7	209.8	1424567.477	740237.86	2559.783	2.765	2.471	1424568.614	740237.24	2559.697	1424566.253	740237.816	2559.254	Unspecified	Unspecified
16	Joint Plane	74.4	68.9	1424561.697	740246.24	2562.712	12.111	4.914	1424560.668	740247.661	2564.344	1424562.709	740245.029	2560.731	Unspecified	Unspecified
17	Joint Plane	33.7	205.5	1424555.636	740255.19	2568.537	1.586	2.887	1424554.89	740256.194	2569.013	1424556.637	740254.051	2568.183	Unspecified	Unspecified
18	Joint Plane	74	72	1424555.4	740252.77	2576.489	13.14	6.073	1424554.46	740253.484	2579.245	1424556.389	740252.156	2573.641	Unspecified	Unspecified
19	Joint Plane	75.9	334.3	1424574.065	740238.789	2560.846	1.025	1.739	1424574.711	740238.946	2561.298	1424573.379	740238.672	2560.213	Unspecified	Unspecified
20	Joint Plane	64.7	340.8	1424574.48	740238.685	2561.563	0.023	0.311	1424574.618	740238.739	2561.557	1424574.323	740238.643	2561.542	Unspecified	Unspecified
21	Joint Plane	70	71.3	1424577.604	740225.286	2557.473	1.787	2.2	1424577.121	740225.947	2558.143	1424578.119	740224.898	2556.487	Unspecified	Unspecified
22	Joint Plane	79.8	73.4	1424580.758	740223.635	2562.287	6.74	3.991	1424581.296	740221.465	2562.449	1424580.392	740225.31	2561.878	Unspecified	Unspecified
23	Joint Plane	48.7	222.7	1424580.677	740229.905	2568.864	12.993	5.495	1424581.931	740231.375	2570.873	1424580.018	740228.109	2566.889	Unspecified	Unspecified
24	Joint Plane	53.7	191.6	1424597.192	740222.367	2570.079	3.126	3.782	1424595.836	740223.285	2571.175	1424597.787	740221.136	2568.75	Unspecified	Unspecified
25	Joint Plane	58.5	198.4	1424600.262	740219.675	2566.832	1.158	1.465	1424600.946	740219.426	2566.77	1424599.508	740219.604	2566.561	Unspecified	Unspecified
26	Joint Plane	64.9	185.5	1424594.384	740222.767	2567.936	0.988	1.906	1424594.223	740223.174	2568.755	1424594.544	740222.337	2567.073	Unspecified	Unspecified
27	Joint Plane	68.6	63.5	1424594.21	740224.173	2569.738	0.647	1.182	1424593.936	740224.172	2570.276	1424594.401	740224.355	2569.205	Unspecified	Unspecified

Appendix D: Structural Data from 3-D Models— Traces

This appendix contains orientation and location information for structures mapped as traces to which planes were fitted. Data for structures mapped as planes are included in Appendix C. Not all outcrop models contain trace data.

Each trace is represented by a series of coordinates that share a single dip and dip direction.

File names shown above the tables correspond to the 3-D model numbers. For example, 1_lines.xls indicates planar data from outcrop model 1.

All coordinates are in Washington State Plane South (feet), NAD83/91, NAVD88

1_lines.xls

Description	E	N	Height	Dip	DDN	RMS Error
2	1426664.421	733572.3284	2564.528472	63.8	316.2	2.793
2	1426665.152	733571.2811	2566.666454	63.8	316.2	2.793
2	1426666.133	733570.7607	2568.484457	63.8	316.2	2.793
2	1426666.646	733570.1908	2570.020865	63.8	316.2	2.793
2	1426666.876	733569.3429	2571.998296	63.8	316.2	2.793
2	1426667.297	733569.4395	2573.050698	63.8	316.2	2.793
2	1426668.724	733569.8795	2574.031217	63.8	316.2	2.793
2	1426669.399	733569.9923	2574.539964	63.8	316.2	2.793
3	1426663.595	733572.5723	2564.119752	40.9	178.9	0.524
3	1426663.035	733572.6027	2564.236621	40.9	178.9	0.524
3	1426662.681	733572.7092	2564.462369	40.9	178.9	0.524
3	1426662.437	733573.088	2564.810577	40.9	178.9	0.524
3	1426661.54	733574.1862	2565.503225	40.9	178.9	0.524
3	1426661.155	733574.4392	2565.736485	40.9	178.9	0.524
3	1426660.612	733574.9864	2566.227412	40.9	178.9	0.524
3	1426660.072	733575.7401	2566.897833	40.9	178.9	0.524
3	1426659.878	733576.0032	2567.3009	40.9	178.9	0.524
3	1426659.642	733576.4036	2567.561367	40.9	178.9	0.524
3	1426659.409	733577.2847	2568.271706	40.9	178.9	0.524
3	1426659.019	733578.3391	2569.211576	40.9	178.9	0.524
3	1426658.879	733579.3162	2569.939219	40.9	178.9	0.524
3	1426658.552	733579.4409	2570.214826	40.9	178.9	0.524
3	1426657.897	733580.2928	2570.998804	40.9	178.9	0.524
3	1426657.44	733580.7017	2571.511464	40.9	178.9	0.524
4	1426666.381	733570.2572	2563.614207	62.9	272.8	0.849
4	1426666.551	733570.0501	2563.857818	62.9	272.8	0.849
4	1426666.678	733570.0209	2564.032795	62.9	272.8	0.849
4	1426666.782	733569.6966	2564.418545	62.9	272.8	0.849
4	1426666.93	733569.2456	2565.030637	62.9	272.8	0.849
4	1426667.122	733569.0992	2565.192763	62.9	272.8	0.849
4	1426667.397	733568.7212	2565.731727	62.9	272.8	0.849
4	1426667.552	733568.3792	2566.097523	62.9	272.8	0.849
4	1426667.709	733568.338	2566.420505	62.9	272.8	0.849
4	1426668.012	733567.7191	2566.986194	62.9	272.8	0.849
4	1426668.542	733567.261	2567.811401	62.9	272.8	0.849
4	1426669.181	733566.8398	2568.928146	62.9	272.8	0.849
4	1426669.591	733566.3859	2570.051518	62.9	272.8	0.849
4	1426669.731	733566.4374	2570.636158	62.9	272.8	0.849
4	1426669.9	733566.5358	2571.156893	62.9	272.8	0.849
4	1426670.019	733566.485	2571.437558	62.9	272.8	0.849
4	1426670.214	733566.4588	2571.59494	62.9	272.8	0.849
4	1426670.4	733566.488	2571.827959	62.9	272.8	0.849
4	1426670.833	733566.6816	2572.323516	62.9	272.8	0.849
6	1426669.93	733562.7152	2553.478473	43.2	177.1	0.204
6	1426670.609	733561.9039	2552.653376	43.2	177.1	0.204
6	1426671.393	733561.3051	2552.140633	43.2	177.1	0.204
6	1426671.752	733560.6306	2551.60775	43.2	177.1	0.204

6	1426672.22	733559.9703	2550.861955	43.2	177.1	0.204
6	1426672.593	733558.8092	2549.555047	43.2	177.1	0.204
6	1426672.734	733557.7003	2548.559175	43.2	177.1	0.204
6	1426672.648	733557.112	2548.112947	43.2	177.1	0.204
6	1426672.782	733556.5132	2547.556494	43.2	177.1	0.204
6	1426672.976	733555.8642	2546.998133	43.2	177.1	0.204

10_lines.xls

Description	E	N	Height	Dip	DDN	RMS Error
1	1426234.899	734927.3146	2560.523581	7.2	84.7	1.007
1	1426234.901	734927.7965	2560.71705	7.2	84.7	1.007
1	1426234.953	734928.0424	2560.72384	7.2	84.7	1.007
1	1426235.014	734928.3835	2560.926588	7.2	84.7	1.007
1	1426234.974	734928.8599	2560.822059	7.2	84.7	1.007
1	1426235.055	734929.4434	2560.734284	7.2	84.7	1.007
1	1426235.247	734929.7948	2560.761132	7.2	84.7	1.007
1	1426235.891	734930.1303	2560.457142	7.2	84.7	1.007
1	1426236.468	734930.3649	2560.438322	7.2	84.7	1.007
1	1426236.712	734930.4873	2560.271418	7.2	84.7	1.007
1	1426238.722	734930.538	2560.348542	7.2	84.7	1.007
2	1426234.469	734927.5726	2561.041711	76.1	213.2	0.89
2	1426234.225	734927.613	2561.484636	76.1	213.2	0.89
2	1426234.21	734927.6339	2561.768071	76.1	213.2	0.89
2	1426234.16	734927.7579	2562.233691	76.1	213.2	0.89
2	1426234.371	734927.855	2562.54981	76.1	213.2	0.89
2	1426234.407	734927.6908	2562.742799	76.1	213.2	0.89
2	1426234.645	734927.6562	2563.061828	76.1	213.2	0.89
2	1426234.744	734927.5264	2563.357166	76.1	213.2	0.89
2	1426236.146	734927.242	2564.61149	76.1	213.2	0.89
2	1426236.307	734927.3057	2565.557564	76.1	213.2	0.89
2	1426236.927	734927.2991	2566.3961	76.1	213.2	0.89

12_lines.xls

Description	E	N	Height	Dip	DDN	RMS Error
1	1426267.178	735144.7008	2558.916223	14.1	129.2	1.342
1	1426266.895	735143.5485	2558.880821	14.1	129.2	1.342
1	1426266.697	735142.5949	2558.746046	14.1	129.2	1.342
1	1426266.682	735141.8174	2558.527211	14.1	129.2	1.342
1	1426266.763	735141.0247	2558.43352	14.1	129.2	1.342
1	1426266.964	735140.5346	2558.355592	14.1	129.2	1.342
2	1426273.056	735172.2234	2563.140945	67.2	203.7	1.929
2	1426272.877	735171.9097	2561.752548	67.2	203.7	1.929
2	1426272.79	735171.7533	2561.060342	67.2	203.7	1.929
2	1426272.425	735171.2705	2560.327792	67.2	203.7	1.929
2	1426272.134	735170.7662	2559.272588	67.2	203.7	1.929

2	1426272.378	735170.6009	2558.522009	67.2	203.7	1.929
2	1426273.075	735169.7574	2557.610668	67.2	203.7	1.929
2	1426272.829	735168.9652	2555.549671	67.2	203.7	1.929
2	1426271.604	735168.5115	2553.163716	67.2	203.7	1.929

23_lines.xls

Description	E	N	Height	Dip	DDN	RMS Error
1	1424148.861	741630.1843	2552.293405	65.5	304.2	1.138
1	1424148.442	741629.9687	2551.898442	65.5	304.2	1.138
1	1424147.952	741629.7175	2551.576875	65.5	304.2	1.138
1	1424147.904	741629.7418	2551.198379	65.5	304.2	1.138
1	1424147.89	741629.8966	2551.044807	65.5	304.2	1.138
1	1424147.721	741629.7237	2550.738621	65.5	304.2	1.138
1	1424147.216	741629.4972	2550.042768	65.5	304.2	1.138
1	1424146.374	741629.416	2548.884304	65.5	304.2	1.138

24_lines.xls

Description	E	N	Height	Dip	DDN	RMS Error
1	1424132.25	741515.315	2556.319905	28.4	331.3	0.991
1	1424132.036	741515.6671	2555.90386	28.4	331.3	0.991
1	1424131.889	741516.0762	2555.736599	28.4	331.3	0.991
1	1424131.998	741516.3974	2555.43139	28.4	331.3	0.991
1	1424131.887	741516.7042	2555.266646	28.4	331.3	0.991
1	1424131.423	741517.2201	2555.075663	28.4	331.3	0.991
1	1424131.133	741517.8537	2554.66458	28.4	331.3	0.991
1	1424131.026	741518.508	2554.271202	28.4	331.3	0.991
1	1424130.641	741519.0806	2553.856206	28.4	331.3	0.991
1	1424130.206	741519.4898	2553.594988	28.4	331.3	0.991
1	1424130.064	741519.9715	2553.358534	28.4	331.3	0.991
1	1424130.302	741520.4121	2553.227611	28.4	331.3	0.991
1	1424130.316	741520.9248	2553.082388	28.4	331.3	0.991

26_lines.xls

Description	E	N	Height	Dip	DDN	RMS Error
1	1424105.912	741355.6246	2545.682389	32.2	216	2.121
1	1424106.399	741356.5839	2546.09525	32.2	216	2.121
1	1424106.606	741357.6575	2546.657144	32.2	216	2.121
1	1424106.684	741358.675	2547.498299	32.2	216	2.121
1	1424106.814	741359.9068	2547.998404	32.2	216	2.121
1	1424106.975	741360.8576	2548.565295	32.2	216	2.121
1	1424107.202	741362.0133	2549.276412	32.2	216	2.121
1	1424107.725	741363.2269	2549.927662	32.2	216	2.121
1	1424108.253	741364.6571	2550.939116	32.2	216	2.121
1	1424108.603	741365.4028	2551.662182	32.2	216	2.121

33_lines.xls

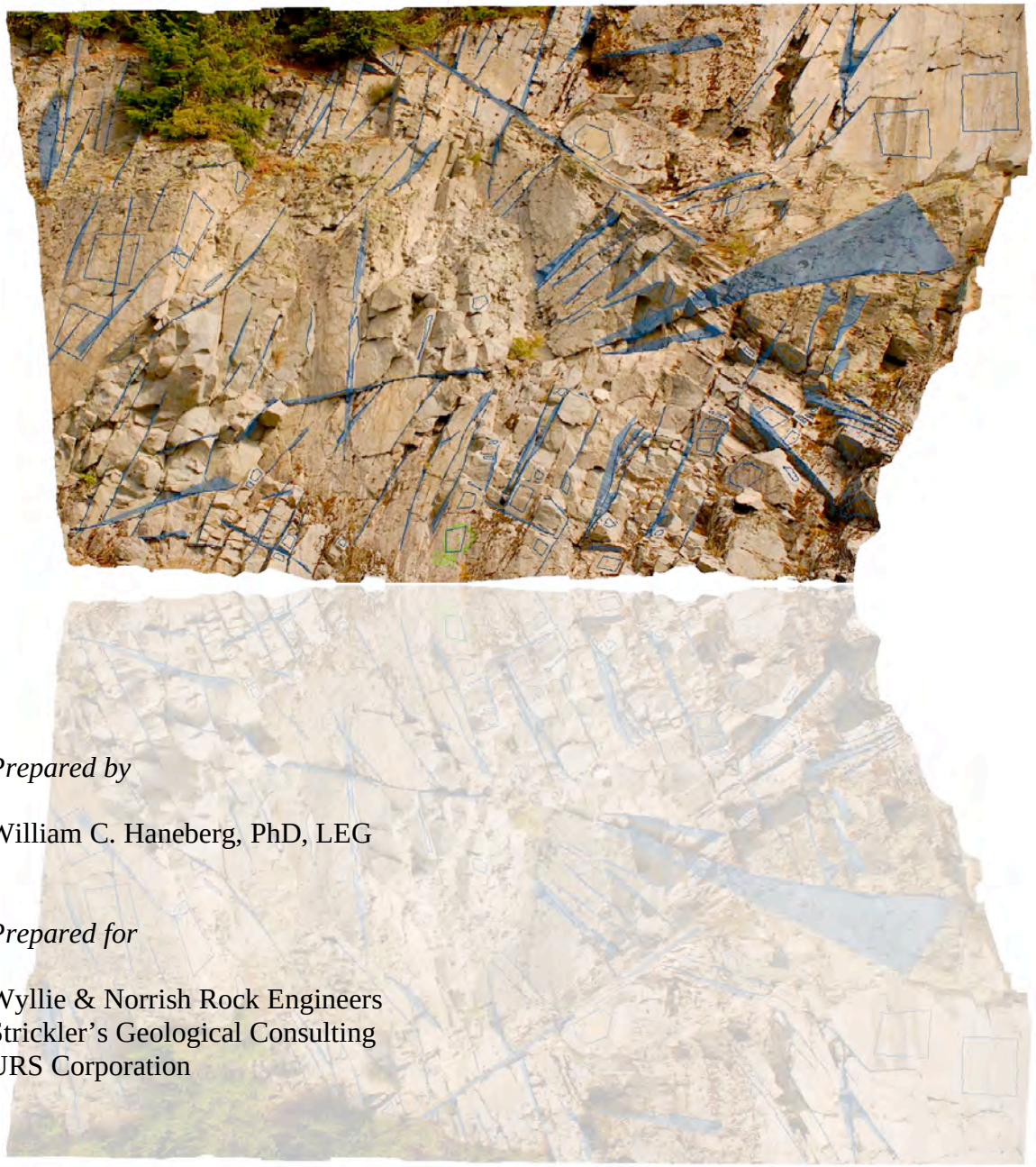
Description	E	N	Height	Dip	DDN	RMS Error
1	1424228.005	740738.0762	2570.152211	25.1	323.3	0.536
1	1424228.674	740737.3361	2570.713993	25.1	323.3	0.536
1	1424229.195	740736.7083	2570.902771	25.1	323.3	0.536
1	1424229.676	740736.3915	2571.162552	25.1	323.3	0.536
1	1424230.575	740735.9741	2571.490819	25.1	323.3	0.536
1	1424231.01	740735.7534	2571.832328	25.1	323.3	0.536
1	1424231.445	740735.2044	2572.188513	25.1	323.3	0.536
1	1424231.724	740734.8677	2572.513649	25.1	323.3	0.536
1	1424232.46	740734.4345	2572.736402	25.1	323.3	0.536
1	1424233.108	740733.6499	2573.231743	25.1	323.3	0.536
1	1424234.036	740732.8568	2573.77725	25.1	323.3	0.536
2	1424188.834	740802.8701	2551.726053	68.8	321.5	2.401
2	1424189.121	740802.8098	2552.374543	68.8	321.5	2.401
2	1424189.946	740803.0403	2553.271875	68.8	321.5	2.401
2	1424190.275	740803.0102	2553.817426	68.8	321.5	2.401
2	1424190.538	740803.001	2554.185313	68.8	321.5	2.401
2	1424190.861	740802.9653	2554.619166	68.8	321.5	2.401
2	1424190.896	740802.9076	2555.159441	68.8	321.5	2.401
2	1424191.316	740802.7986	2555.787731	68.8	321.5	2.401
2	1424191.89	740802.9487	2556.544726	68.8	321.5	2.401
2	1424192.257	740802.9317	2557.239842	68.8	321.5	2.401
2	1424193.041	740803.0153	2558.220053	68.8	321.5	2.401
2	1424193.629	740803.1671	2558.824257	68.8	321.5	2.401

41_lines.xls

Description	E	N	Height	Dip	DDN	RMS Error
1	1424555.676	740256.7559	2571.940127	77.7	334.2	3.686
1	1424555.071	740255.8886	2574.635011	77.7	334.2	3.686
1	1424554.62	740255.2108	2576.902243	77.7	334.2	3.686
1	1424554.25	740254.6189	2578.848838	77.7	334.2	3.686
1	1424554.069	740254.2245	2580.203685	77.7	334.2	3.686
1	1424554.123	740253.7981	2581.35399	77.7	334.2	3.686
1	1424554.364	740253.7105	2582.580636	77.7	334.2	3.686
1	1424554.761	740253.5244	2583.794913	77.7	334.2	3.686
1	1424555.396	740253.3507	2584.84176	77.7	334.2	3.686
1	1424556.934	740254.2725	2586.021704	77.7	334.2	3.686
2	1424557.272	740251.8608	2571.556613	84.1	316.9	2.927
2	1424556.784	740251.1423	2573.125065	84.1	316.9	2.927
2	1424556.799	740251.3362	2575.236201	84.1	316.9	2.927
2	1424556.455	740250.6878	2576.113759	84.1	316.9	2.927
2	1424556.185	740250.7105	2577.788542	84.1	316.9	2.927
2	1424556.176	740250.7184	2579.202975	84.1	316.9	2.927
2	1424556.384	740250.9464	2580.197723	84.1	316.9	2.927
2	1424556.52	740250.5452	2580.438825	84.1	316.9	2.927

2	1424556.624	740250.4816	2580.861579	84.1	316.9	2.927
2	1424557.132	740250.6719	2581.232811	84.1	316.9	2.927
2	1424557.193	740250.7535	2582.392969	84.1	316.9	2.927
2	1424558.036	740251.5452	2583.163348	84.1	316.9	2.927
2	1424558.838	740252.5431	2583.769929	84.1	316.9	2.927

Digital Outcrop Modeling and Structural Mapping, I-90 Snoqualmie Pass East, Hyak to Keechelus Dam, Washington (2007 Field Season)



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Prepared for

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Strickler's Geological Consulting
URS Corporation

March 24, 2008

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Purpose

Digital 3-D models of selected rock exposures along the westbound lane of I-90 between Hyak and Keechelus Dam were created using close range terrestrial digital photogrammetry and used for structural mapping in support of rock slope design along the highway. The work described in this report was a continuation of that undertaken during the 2006 field season, for which a previous report was prepared.

This report contains a description of the 2007 fieldwork and data processing, screen-capture images of each 3-D model for which structural mapping was performed, and appendices containing the digital models and the orientations and locations of measured rock mass discontinuities.

Sirovision 3.2 software, developed and supported by the Commonwealth Scientific and Industrial Research Organization (CSIRO) Mining and Exploration Division, was used to create the 3-D outcrop models. The software consists of two applications: Siro3D for 3-D model creation and SiroJoint for structural mapping and analysis. Additional information about the software is available at www.sirovision.com. Virtual structural mapping of rock faces using 3-D photogrammetric models is an established method that has been successfully applied on projects involving highway cuts (including nearby portions of I-90), surface mines and quarries, and underground mines (e.g., Haneberg, in press; Haneberg and Medley, 2007; Haneberg *et al*, 2007; Haneberg *et al*, 2006; Poropat, 2006; Tonon and Kottenstette, 2006).

Fieldwork

Most of the stereo pairs of photographs used in the 2007 work were taken in July and August 2007 by Strickler's Geological Consulting and provided to Haneberg Geoscience for processing. A few were taken by Haneberg Geoscience as part of the 2006 fieldwork for this project, for which a separate report was prepared, but mapped and analyzed as part of the 2007 work described in this report. Photographs taken the 2006 field season were assigned two-digit numbers (e.g., 42) and referred to as the 000 series. Photographs taken during the 2007 field season were assigned three-digit numbers (e.g., 101 or 202) and referred to as the 100 and 200 series.

The photographs were taken using Nikon D200 digital SLR cameras with Nikkor AF-D 20 mm f2.8, AF-D 24 mm f2.8, or AF-D 50 mm f1.8 lenses, all of which are supported by the Sirovision software used in this project, mounted on a standard camera tripod with a pan head. Beyond the use of a camera and lenses supported by the software, no special calibration was performed for this routine structural mapping. A plumb bob used to mark each camera station and a retractable steel tape used to measure camera height at each station. The files were saved as native Nikon NEF (also known as RAW) files to allow for greater processing flexibility and lossless conversion to the tiff format required by Sirovision.

Camera stations were marked on the shoulder or Jersey barrier of the eastbound lane of I-90. Control points were marked and numbered on the modeled rock faces using spray paint. The locations of both the camera stations and control points were later surveyed with RTK GPS and a total station by White Shield, Inc. and the coordinates provided in an Excel spreadsheet (Appendix A and data DVDs). This information was used to establish the scale, orientation, and geo-referenced coordinates of the 3-D models within the Washington State Plane coordinate system (NAD 83 and NAVD 88). The locations of the surveyed control points for both the 2006 and 2007 photographs are superimposed on a USGS 1 m orthophoto in Figure 1.

Image Processing and 3-D Model Creation

The digital photographs were first converted from NEF format, which allows for maximum flexibility if any image adjustments are necessary, to the tiff format required by Sirovision. Each photograph was then corrected to remove lens distortion using the default Sirovision parameters for the appropriate lens, and each pair was combined with the survey information to set up the 3-D orientation for each pair. This processes uses the camera station, camera height, and control point locations for each model and requires that the surveyed control point and three other common (but not surveyed) points be identified in each photograph. A 3-D model area was then defined for each pair, using as much of the overlap area as was practical in each case. Irregular topography, trees, and brush along the tops of the road cuts complicated this task and, as a consequence, some of the models are either truncated along their top edge or contain irregularities near the trees and brush. Finally, 3-D models were generated using batch processing within Sirovision, which included automated evaluation of matching success. Each 3 by 3 block of pixels in the defined overlap area yielded one spatial data point on the outcrop face, which yielded models typically consisting of approximately several hundreds of thousands xyz points each. The models were saved as Sirovision rectified tiff files containing 3-D information. Other formats, including ascii xyz or dxf files of the underlying 3-D meshes, were not exported but are available upon request.

Digital copies of all of the 3-D models are included as specially formatted Siro3D tiff files on data DVDs provided to Wyllie & Norrish Rock Engineers and Strickler's Geological Consulting.

Warning: Although the 3-D tiff files included on the data DVDs can be opened and viewed by many computer programs, saving them under the same file name will likely cause the 3-D information to be removed from the file. Sirovision3-D tiff files can be viewed, rotated, and zoomed using a free viewer available from www.sirovision.com (use the Import command for Siro3D tiff files).

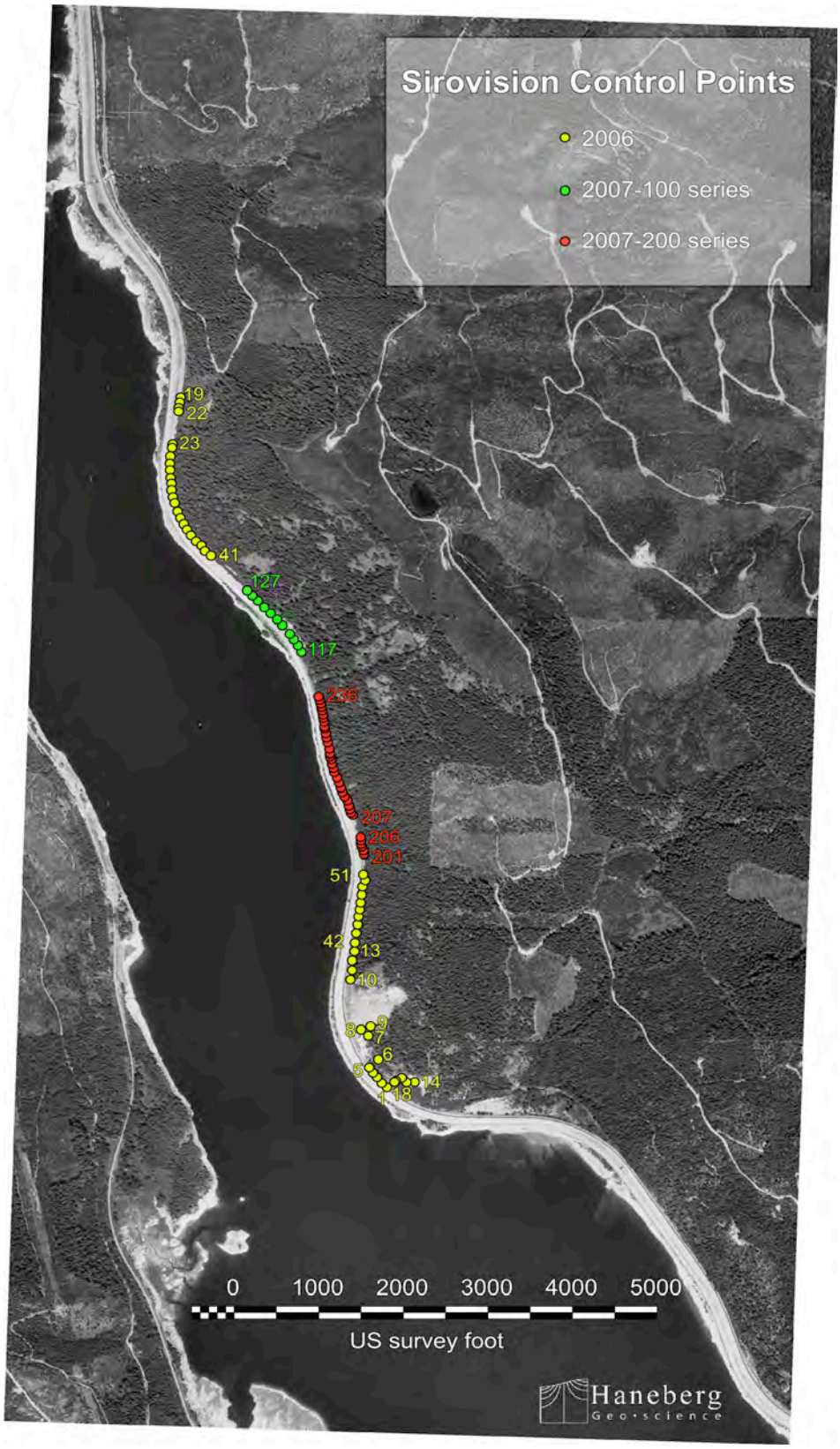

Figure 1. Control point layout for Slide Curve outcrop models.

Structural Mapping

Virtual structural mapping of selected rock mass discontinuities and lithologic contacts was performed between November 2007 and January 2008. This included two initial sessions at the Seattle URS office, during which a laptop computer running the SiroJoint component of Sirovision was connected to a 23 inch high resolution computer monitor to allow collaborative mapping of significant structures by representatives of Haneberg Geoscience, Wyllie & Norrish Rock Engineers, and Strickler's Geological Consulting. Additional mapping was subsequently performed by Haneberg Geoscience, reviewed by Strickler's Geological Consulting, and revised with the addition of additional discontinuities pertinent to the rock slope design. Figure 2 shows a typical SiroJoint model with a number of joint surfaces mapped as closed polygons and traces intersecting the rock surface.

Each SiroJoint model includes joint and fault surfaces identified during collaborative mapping, the orientations of which were exported and delivered electronically to Wyllie & Norrish Rock Engineers and Strickler's Geological Consulting for further plotting, analysis, and incorporation into slope designs. In addition to dip angles and dip directions, SiroJoint calculates the coordinates of the center, area, maximum chord length, the coordinates of the top and bottom edges for joints mapped as polygons. The coordinates of each point defining 3-D traces to which planes were fitted were also exported.

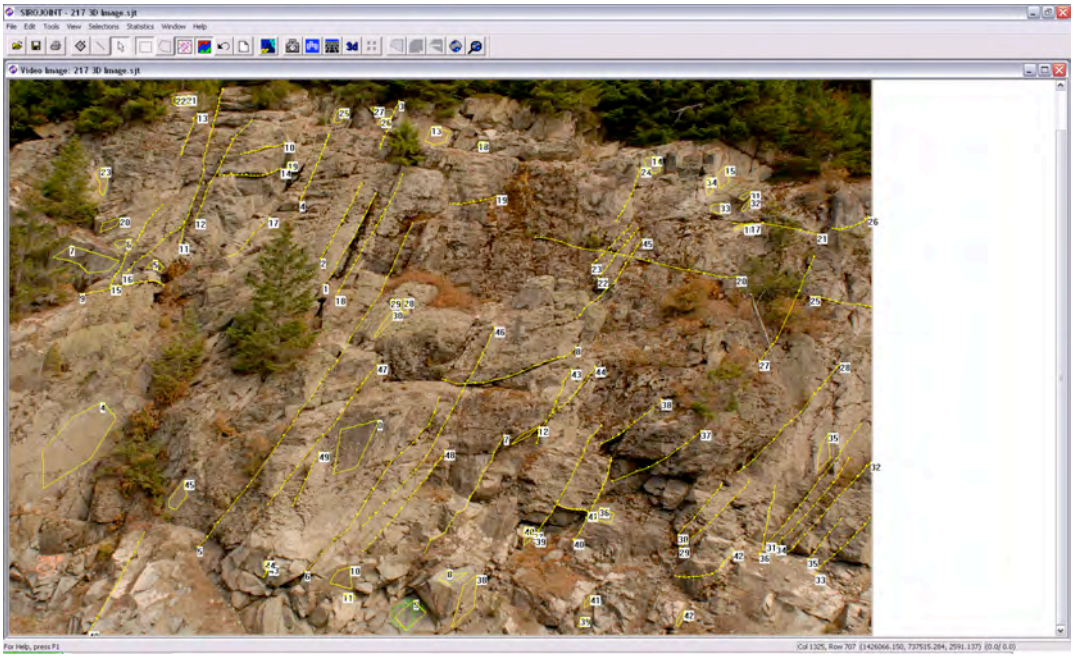

Figure 2. SiroJoint 3-D model 217 from the I-90 Hyak to Keechelus Dam project, showing mapped joint planes as numbered yellow polygons and traces as numbered yellow lines. Dips and dip directions were calculated by Sirovision, using best-fit planes to the polygons and traces. The polygon and line ID numbers in the image correspond to those listed in Appendices D and E and on the data DVDs.

Screen captures of the SiroJoint models are included in Appendix C of this report. SiroJoint 3-D models showing the mapped discontinuities and comma-delimited (CSV) text files containing the exported structural data are included on the report DVD (Appendices D, E, and F). Because of their sizes, Appendices D, E, and F are provided only as electronic data files.The SiroJoint models (.sjt files) can be viewed using the Open command in the free Sirovision viewer (available from www.sirovision .com). The discontinuity data files (.csv) can be opened using a text editor such as WordPad (not Notepad) or spreadsheet programs such as Excel (it may be necessary to choose All Files for file type).

Discontinuity orientations measured using Sirovision were compared to orientations measured manually using a geologic compass by Strickler's Geological Consulting. Twenty-one planes were compared, with one to three manual measurements and one or two Sirovision measurements for each plane. In cases where more than one measurement was made, the average orientation of the plane was estimated as a resultant dipline calculated using vector addition. Differences between the manual and Sirovision dipline vectors (or resultants in the case of multiple measurements) are tabulated in Appendix B, in which the angle α separating the two resultants **v** and **w** is, from basic vector analysis,

$$\cos\alpha = \frac{\mathbf{v} \bullet \mathbf{w}}{\|\mathbf{v}\| \, \|\mathbf{w}\|}$$

in which the vertical double bars indicate the vector norm (if both vectors are unit vectors, their norms are unity and the denominator vanishes). The agreement between manual and Sirovision orientations is very good, in most cases with only 1° to 3° between the two resultant dipline vectors, which is well within the range of imprecision that one might expect from the manually measured orientations (Cronin, in press). Differences between manual and Sirovision dip angles and dip directions are also given for comparison. Note that dip direction differences can be extremely large for steeply dipping planes that are separated by a small 3-D angles even if the 3-D angle between the two planes is very small; the situation is compounded when three or more planes are considered. Hence, the dot product difference between two resultant diplines appears to be the most representative measurement of difference or similarity.

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Appendix A: Surveyed Camera and Control Point Locations

I-90 Snoqualmie Pass East - Hyak to Keechelus Dam

WSDOT Contract: Y-9764
WSDOT Project Number XL-2779
2007 Sirovision Control and targets
(Combine Factor = 0.99988231 West Control) WSDOT PD = SPC / CF + 328083.333

Units: U.S. Feet
Vertical: NAVD 1988
Zone: Washington Coordinate System, South Zone, NAD 1983/91

WSI-ID	State Plane Northing	Easting	Elevation	Description
17943	736527.95	1426388.73	2551.20	PMS C101
17946	736513.44	1426279.05	2537.09	PMS C101L
17947	736494.47	1426281.69	2536.82	PMS C101R
17942	736649.47	1426359.54	2545.06	PMS C102
17944	736625.64	1426257.79	2537.76	PMS C102L
17945	736606.86	1426261.90	2537.64	PMS C102R
17935	736995.87	1426246.56	2548.13	PMS C103
17937	736969.86	1426147.91	2541.11	PMS C103L
17936	736950.97	1426155.09	2540.95	PMS C103R
17934	737114.82	1426210.23	2550.33	PMS C104
17939	737074.16	1426106.69	2541.83	PMS C104L
17938	737050.59	1426116.21	2541.71	PMS C104R
17923	737202.26	1426165.84	2545.72	PMS C105
17925	737178.86	1426064.63	2542.12	PMS C105L
17924	737159.39	1426072.38	2542.08	PMS C105R
17922	737309.33	1426123.39	2542.58	PMS C106
17927	737274.68	1426026.97	2542.33	PMS C106L
17926	737254.99	1426034.49	2542.29	PMS C106R
17921	737432.09	1426082.13	2547.04	PMS C107
17929	737382.40	1425987.73	2542.37	PMS C107L
17928	737363.02	1425994.53	2542.36	PMS C107R
17920	737539.85	1426044.57	2544.01	PMS C108
17931	737512.18	1425946.03	2542.10	PMS C108L
17930	737492.90	1425951.75	2542.17	PMS C108R
17913	737641.52	1426017.20	2542.35	PMS C109
17915	737623.34	1425916.26	2541.20	PMS C109L
17914	737603.57	1425921.24	2541.49	PMS C109R
17912	737747.22	1425990.77	2542.30	PMS C110
17917	737734.41	1425891.79	2539.68	PMS C110L
17916	737714.38	1425895.99	2540.00	PMS C110R
17905	737876.70	1425964.27	2538.65	PMS C111
17908	737852.86	1425870.01	2538.67	PMS C111L
17909	737830.75	1425873.82	2538.81	PMS C111R
17904	737986.66	1425949.81	2538.93	PMS C112
17906	737973.38	1425850.19	2537.46	PMS C112L

17907	737953.51	1425853.29	2537.73	PMS C112R
17899	738086.39	1425933.55	2539.72	PMS C113
17900	738089.92	1425831.26	2536.29	PMS C113L
17901	738069.72	1425834.36	2536.50	PMS C113R
17898	738213.53	1425918.23	2543.73	PMS C114
17894	738205.48	1425812.59	2535.36	PMS C114L
17895	738184.91	1425815.69	2535.49	PMS C114R
17897	738349.32	1425892.72	2540.34	PMS C115
17892	738341.39	1425788.41	2534.55	PMS C115L
17893	738321.14	1425792.01	2534.61	PMS C115R
17896	738414.71	1425873.19	2540.08	PMS C116
17890	738411.56	1425773.60	2534.27	PMS C116L
17891	738394.80	1425777.35	2534.36	PMS C116R
17887	739001.08	1425661.72	2542.78	PMS C117
17881	738971.14	1425566.18	2536.69	PMS C117L
17882	738956.80	1425573.64	2536.60	PMS C117R
17886	739084.06	1425621.09	2545.34	PMS C118
17879	739025.10	1425534.92	2537.44	PMS C118L
17880	739011.41	1425543.71	2537.28	PMS C118R
17885	739159.57	1425572.07	2544.36	PMS C119
17877	739090.01	1425487.95	2538.45	PMS C119L
17878	739076.98	1425496.97	2535.65	PMS C119R
17872	739230.38	1425524.67	2546.23	PMS C120
17875	739158.18	1425408.49	2541.26	PMS C120L
17876	739141.98	1425420.55	2540.78	PMS C120R
17869	739337.13	1425436.13	2549.34	PMS C121
17873	739252.32	1425339.90	2543.34	PMS C121L
17874	739236.14	1425351.51	2543.15	PMS C121R
17868	739410.21	1425374.79	2554.56	PMS C122
17860	739329.53	1425271.80	2545.36	PMS C122L
17861	739314.03	1425285.14	2544.94	PMS C122R
17867	739487.40	1425297.82	2554.49	PMS C123
17858	739408.32	1425200.31	2547.17	PMS C123L
17859	739394.55	1425213.58	2546.88	PMS C123R
17866	739561.45	1425222.85	2551.72	PMS C124
17856	739486.48	1425126.39	2549.50	PMS C124L
17857	739471.82	1425138.44	2549.23	PMS C124R
17865	739646.43	1425146.56	2552.33	PMS C125
17854	739550.97	1425061.88	2550.83	PMS C125L
17855	739537.78	1425075.76	2550.62	PMS C125R
17863	739710.83	1425081.28	2552.47	PMS C126
17852	739632.37	1424984.43	2547.75	PMS C126L
17853	739617.02	1424999.17	2548.15	PMS C126R
17862	739773.25	1425020.09	2552.96	PMS C127
17850	739692.97	1424939.97	2545.39	PMS C127L
17851	739679.13	1424951.84	2545.11	PMS C127R

Additional Sirovsion Points located 10/10/07

22823	736469.08	1426400.99	2550.75	PMS C-201
22821	736475.96	1426283.97	2536.59	PMS C-201L
22822	736459.46	1426285.75	2536.44	PMS C-201R
22824	736516.09	1426395.06	2549.24	PMS C-202
22819	736516.43	1426278.54	2537.11	PMS C-202L

22820	736502.15	1426280.68	2536.94	PMS C-202R
22825	736565.34	1426374.46	2547.13	PMS C-203
22817	736556.73	1426271.84	2537.17	PMS C-203L
22818	736541.47	1426274.50	2537.16	PMS C-203R
22826	736599.71	1426366.15	2546.30	PMS C-204
22815	736591.74	1426265.01	2537.49	PMS C-204L
22816	736577.64	1426267.84	2537.34	PMS C-204R
22827	736644.00	1426364.33	2546.16	PMS C-205
22813	736629.11	1426256.91	2537.75	PMS C-205L
22814	736614.65	1426260.24	2537.68	PMS C-205R
22828	736686.72	1426361.62	2552.04	PMS C-206
22811	736664.49	1426248.50	2537.98	PMS C-206L
22812	736649.91	1426251.93	2537.87	PMS C-206R
22808	736962.78	1426269.98	2554.04	PMS C-207
22802	736934.39	1426161.46	2540.66	PMS C-207L
22803	736920.13	1426166.73	2540.51	PMS C-207R
22807	736988.77	1426246.84	2545.85	PMS C-208
22800	736967.04	1426148.96	2541.00	PMS C-208L
22801	736952.60	1426154.51	2540.89	PMS C-208R
22806	737031.75	1426233.88	2546.14	PMS C-209
22798	737002.96	1426135.05	2541.23	PMS C-209L
22799	736988.99	1426140.50	2541.15	PMS C-209R
22804	737079.28	1426221.47	2552.18	PMS C-210
22775	737054.02	1426114.92	2541.65	PMS C-210L
22774	737039.87	1426120.51	2541.55	PMS C-210R
22795	737145.13	1426205.19	2555.02	PMS C-211
22777	737107.25	1426093.40	2541.87	PMS C-211L
22776	737092.06	1426099.46	2541.83	PMS C-211R
22794	737192.65	1426171.24	2545.88	PMS C-212
22779	737158.30	1426072.98	2542.08	PMS C-212L
22778	737144.13	1426078.69	2542.02	PMS C-212R
22793	737250.10	1426144.21	2543.62	PMS C-213
22781	737211.98	1426051.47	2542.21	PMS C-213L
22780	737198.83	1426056.79	2542.17	PMS C-213R
22792	737301.91	1426126.62	2543.60	PMS C-214
22783	737266.16	1426030.30	2542.31	PMS C-214L
22782	737252.96	1426035.35	2542.29	PMS C-214R
22791	737365.28	1426106.13	2542.58	PMS C-215
22785	737330.16	1426006.27	2542.32	PMS C-215L
22784	737316.65	1426011.22	2542.30	PMS C-215R
22790	737430.69	1426082.78	2547.75	PMS C-216
22787	737403.54	1425980.32	2542.35	PMS C-216L
22786	737389.51	1425985.13	2542.37	PMS C-216R
22789	737500.43	1426049.60	2539.52	PMS C-217
22763	737476.36	1425956.75	2542.24	PMS C-217L
22764	737463.18	1425960.77	2542.28	PMS C-217R
22788	737551.99	1426040.09	2544.30	PMS C-218
22761	737537.47	1425938.91	2542.06	PMS C-218L
22762	737524.32	1425942.43	2542.09	PMS C-218R
22771	737604.39	1426022.75	2541.09	PMS C-219
22759	737585.68	1425925.98	2541.75	PMS C-219L
22760	737573.23	1425929.02	2541.90	PMS C-219R
22770	737662.11	1426015.02	2548.57	PMS C-220
22757	737641.88	1425911.69	2541.00	PMS C-220L

22758	737627.71	1425915.29	2541.18	PMS C-220R
22769	737695.95	1425999.81	2539.28	PMS C-221
22755	737682.01	1425902.83	2540.46	PMS C-221L
22756	737669.31	1425905.39	2540.64	PMS C-221R
22768	737731.68	1425998.82	2545.38	PMS C-222
22753	737722.56	1425894.27	2539.89	PMS C-222L
22754	737709.58	1425896.95	2540.09	PMS C-222R
22766	737791.36	1425992.00	2548.33	PMS C-223
22744	737775.11	1425884.05	2539.34	PMS C-223L
22745	737761.82	1425886.59	2539.50	PMS C-223R
22765	737870.79	1425971.88	2544.44	PMS C-224
22742	737852.07	1425870.28	2538.86	PMS C-224L
22743	737839.72	1425872.33	2538.93	PMS C-224R
22750	737932.09	1425957.52	2541.21	PMS C-225
22740	737925.48	1425858.03	2538.29	PMS C-225L
22741	737913.43	1425859.95	2538.39	PMS C-225R
22749	737986.36	1425950.23	2541.85	PMS C-226
22738	737979.63	1425849.32	2537.57	PMS C-226L
22739	737966.40	1425851.45	2537.72	PMS C-226R
22748	738047.13	1425937.68	2539.11	PMS C-227
22736	738033.30	1425840.20	2537.03	PMS C-227L
22737	738020.19	1425842.42	2537.16	PMS C-227R
22747	738071.46	1425933.28	2539.47	PMS C-228
22725	738073.90	1425833.70	2536.50	PMS C-228L
22726	738060.28	1425835.86	2536.61	PMS C-228R
22746	738133.57	1425930.07	2546.02	PMS C-229
22723	738118.46	1425826.72	2536.14	PMS C-229L
22724	738105.07	1425828.90	2536.19	PMS C-229R
22733	738175.85	1425920.23	2541.29	PMS C-230
22721	738172.67	1425817.80	2535.48	PMS C-230L
22722	738158.79	1425820.10	2535.52	PMS C-230R
22732	738216.04	1425917.53	2544.61	PMS C-231
22719	738216.92	1425810.70	2535.31	PMS C-231L
22720	738203.30	1425812.89	2535.37	PMS C-231R
22731	738270.26	1425905.88	2541.42	PMS C-232
22717	738259.08	1425803.47	2535.08	PMS C-232L
22718	738246.04	1425805.63	2535.22	PMS C-232R
22730	738313.98	1425899.54	2543.30	PMS C-233
22715	738304.64	1425795.03	2534.70	PMS C-233L
22716	738290.78	1425797.65	2534.76	PMS C-233R
22729	738357.04	1425890.72	2541.22	PMS C-234
22713	738353.77	1425785.88	2534.55	PMS C-234L
22714	738336.88	1425789.29	2534.58	PMS C-234R
22728	738404.74	1425877.79	2540.18	PMS C-235
22711	738395.71	1425777.11	2534.37	PMS C-235L
22712	738382.86	1425779.96	2534.46	PMS C-235R
22727	738447.27	1425864.47	2543.22	PMS C-236
22709	738438.59	1425766.99	2534.26	PMS C-236L
22710	738423.69	1425770.73	2534.27	PMS C-236R

Appendix B: Comparison of Manual and Sirovision Rock Mass Discontinuity Orientation Measurements

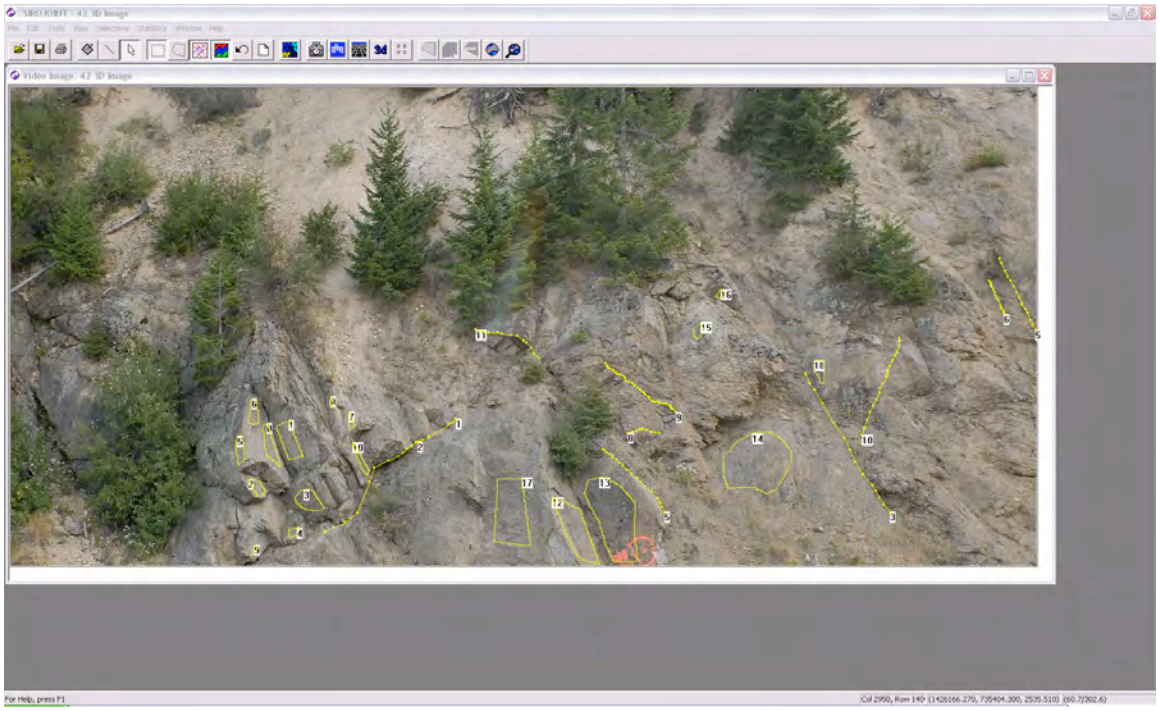
Joint	Manual Measurement		Description	Sirovision Measurement		Manual Resultant		Sirovision Resultant		Resultant Difference		
	Dip	Dip Direction		Dip	Dip Direction	Dip	Dip Direction	Dip	Dip Direction	Dip	Dip Direction	3-D Angular
Fault	52	176	Fault	55	180	52	176	55	180	3	4	4
	77	066										
1	76	070	Red X, Between C202, C203	81	070							
	81	070				78	69	81	70	3	1	3
	45	198										
2	46	196	Orange X, Between C202, C203	44	203	45	200	44	203	-1	3	2
	44	206										
1	88	266	Red X, Below C206	85	266	85	268	85	266	0	-2	0
	82	269										
2	53	336	Orange X, Below C206	57	346	52	339	57	346	5	7	7
	51	341										
	88	226		89	046							
1	88	033	Red X, at C-207	89	231	89	36	90	318	1	282	1
	86	042										
	90	245										
1	88	252	Red X, at C-211	89	251	90	253	89	251	-1	-2	1
	89	071										
1	35	214	Red X, C214 to C213	37	229	37	214	37	229	0	15	12
	39	215										
2	86	066	Orange X, C214 to C213	89	249	87	66	89	249	2	183	4
	88	067										
1	74	035	Red X, C216	77	037	75	37	77	37	2	0	2
	76	039										

2	50 54	338 337	Orange X, C216	50	340	52	338	50	340	-2	2	3
1	87 89	099 099	Red X, C219	89 88	273 278	88	99	89	276	1	177	3
1	74 76	295 297	Red X, C221	76	296	75	296	76	296	1	0	1
1	72 73	066 067	Red X, C222	75 76	070 071	73	66	76	70	3	4	3
2	66 66 65	282 284 284	Orange, C222	64	282	66	283	64	282	-2	-1	2
3	40 40 41	211 210 209	Green, C222	42 44	214 205	40	210	43	210	3	0	3
1	80 79	064 064	Red X	81	067	79	64	81	67	2	3	2
1	82 86	042 044	Red X	N/A	N/A							
1	80 78	073 073	Red X, C122	86	065	79	73	86	65	7	-8	7
1	75 76	079 075	Red X, C122 to C123	75	77	76	77	75	77	-1	0	1
1	76 73 73	072 067 071	Red X, C124	76 76	72 69	74	70	76	70	2	0	2
2	65 68	341 343	Orange X, C124	64	340	67	342	64	340	-3	-2	3

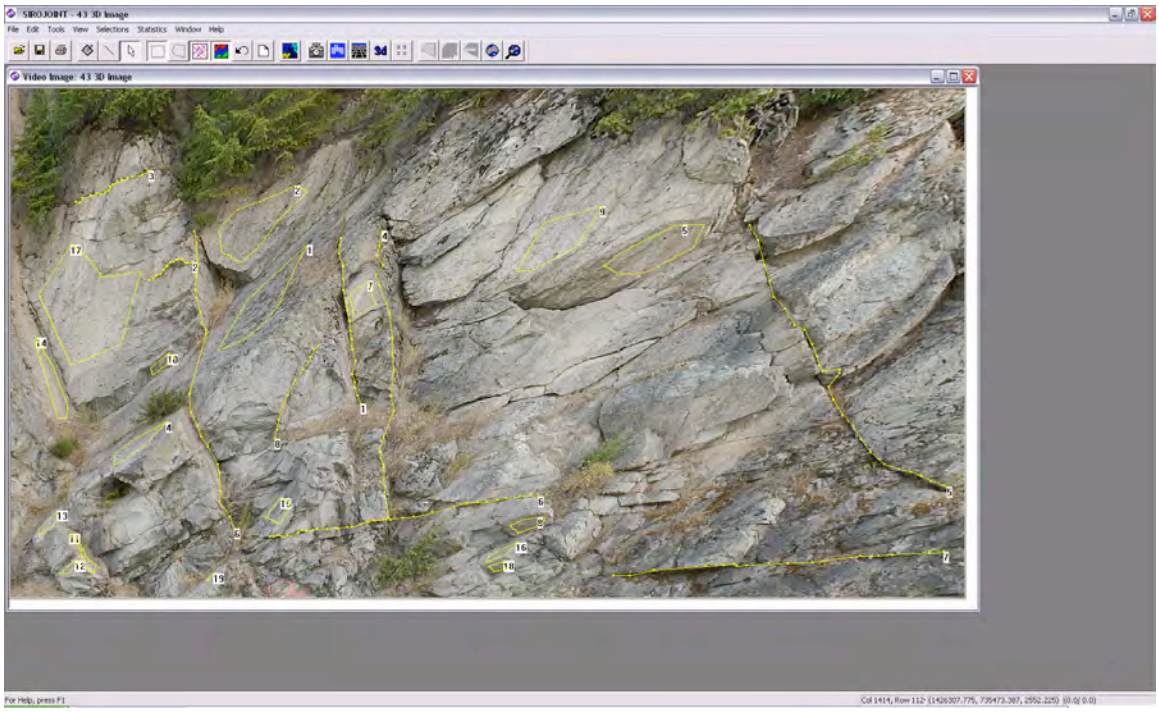
Appendix C: SiroJoint Screenshots

The images in Appendix C are two-dimenional projections of the 3-D outcrop models. Model numbers below each screenshot refer to the control points shown in Figure 1.

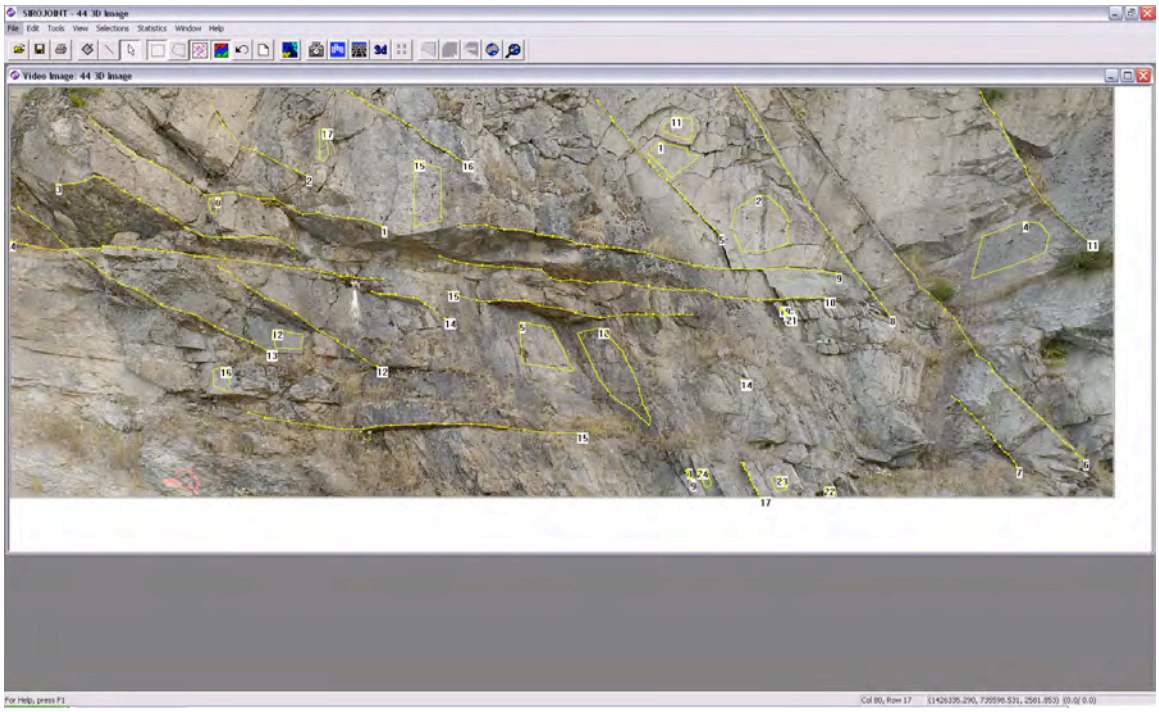
Digital SiroJoint 3-D models that can be opened and manipulated using SiroJoint software or the free Sirovision viewer (www.sirovision.com) are included on the data DVD as Appendix D. Joint ID numbers shown in the screenshots are keyed to orientations listed in Appendices E (polygons/planes) and F (traces/lines) on the data DVD.



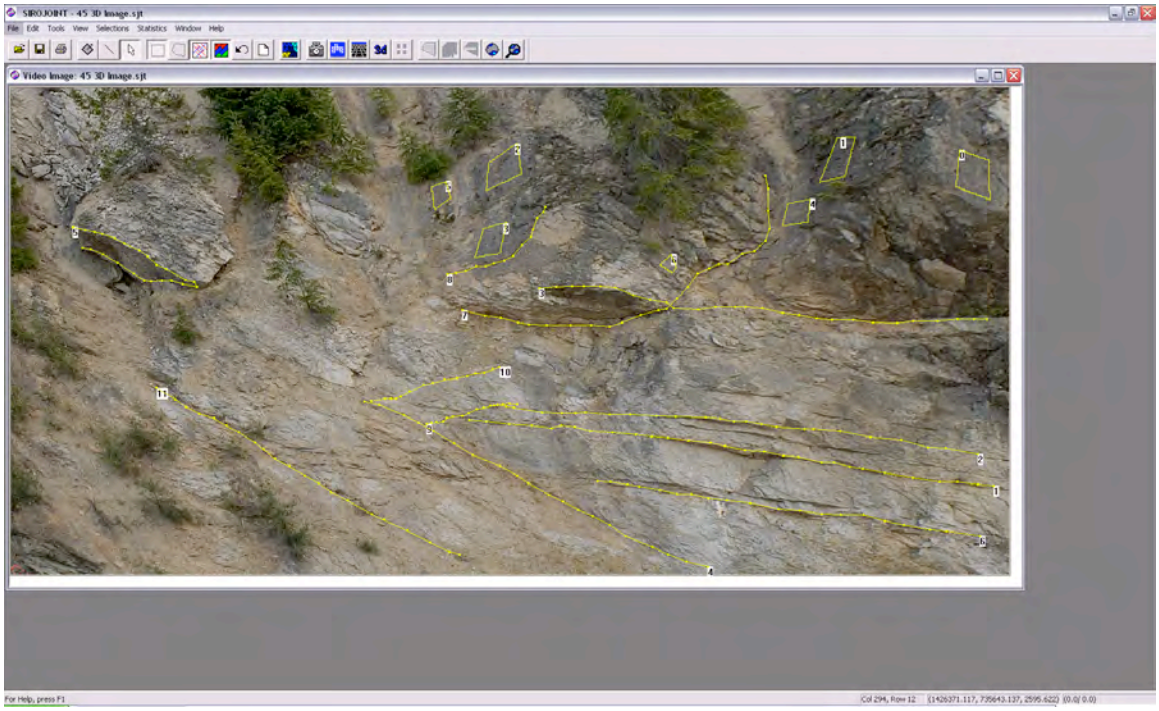
Outcrop model 042



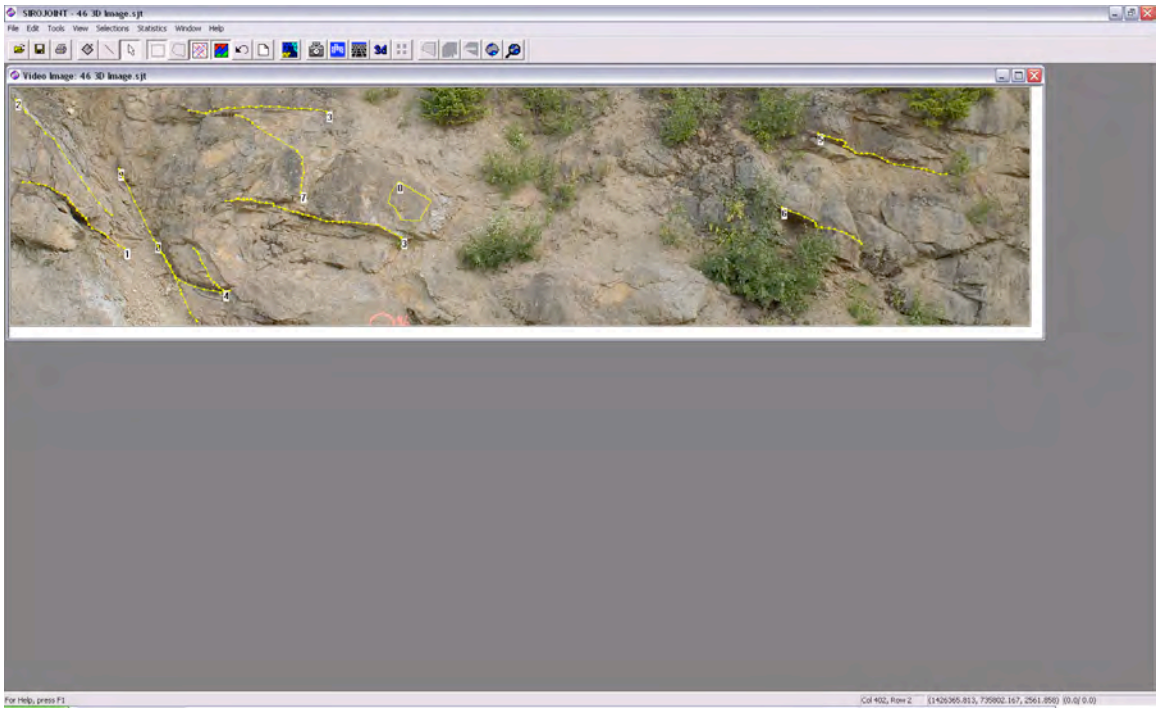
Outcrop model 043



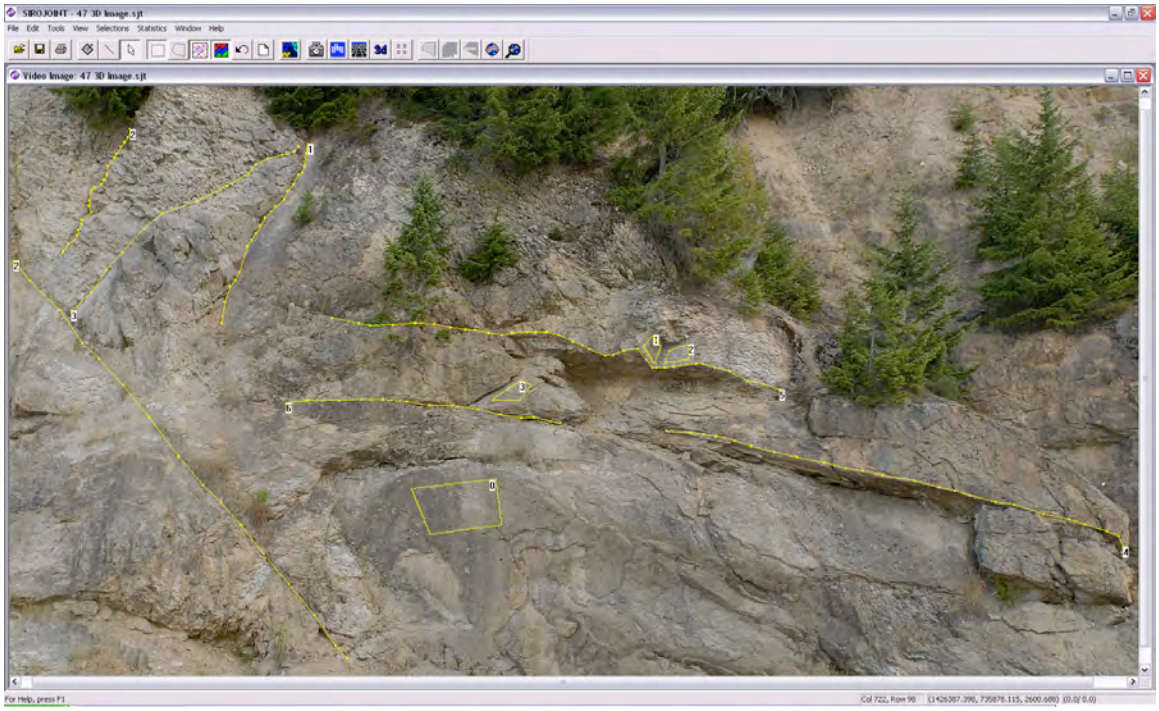
Outcrop model 044



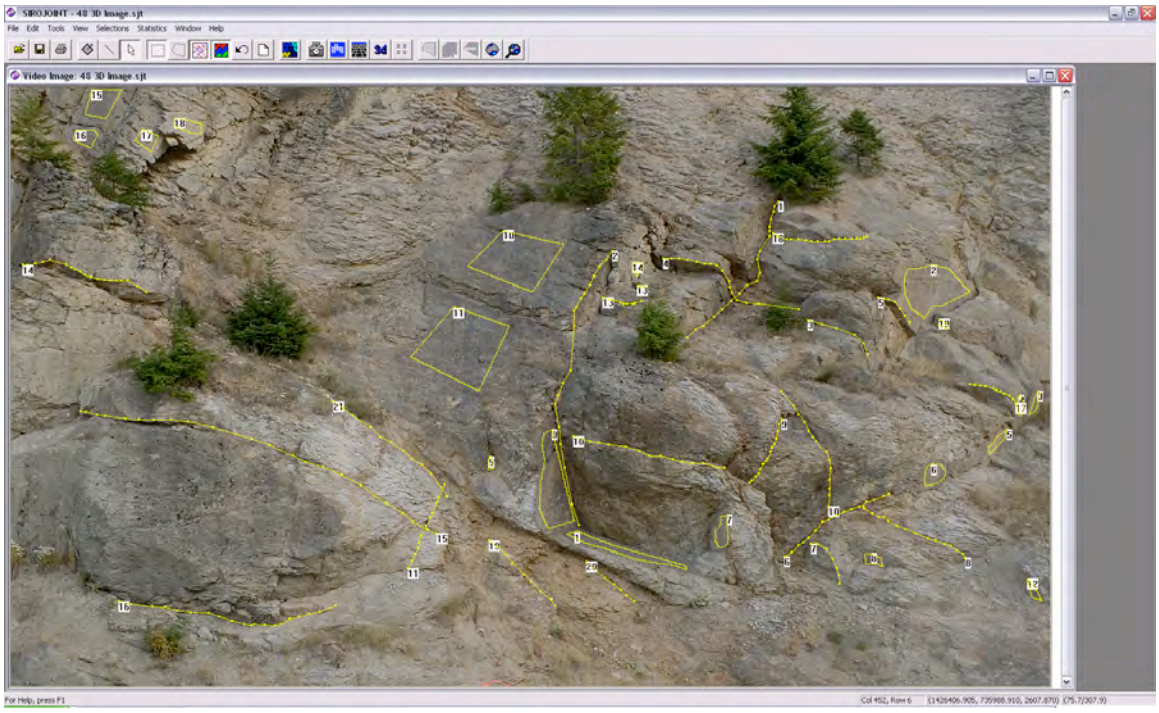
Outcrop model 045



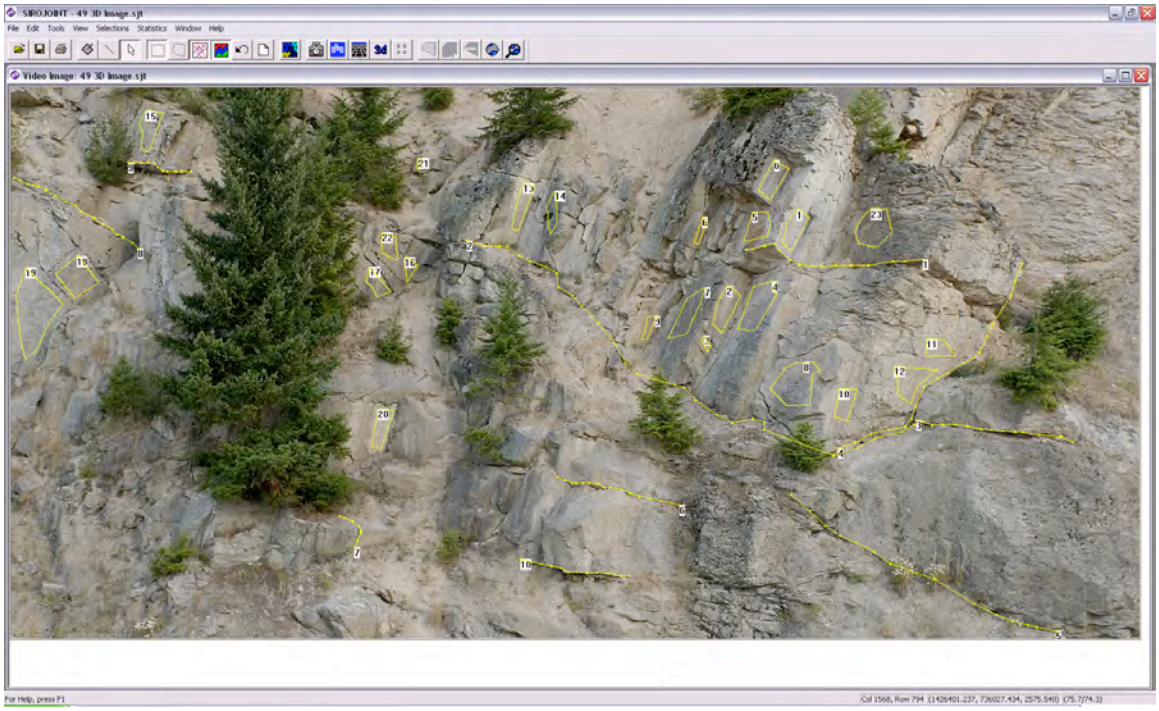
Outcrop model 046



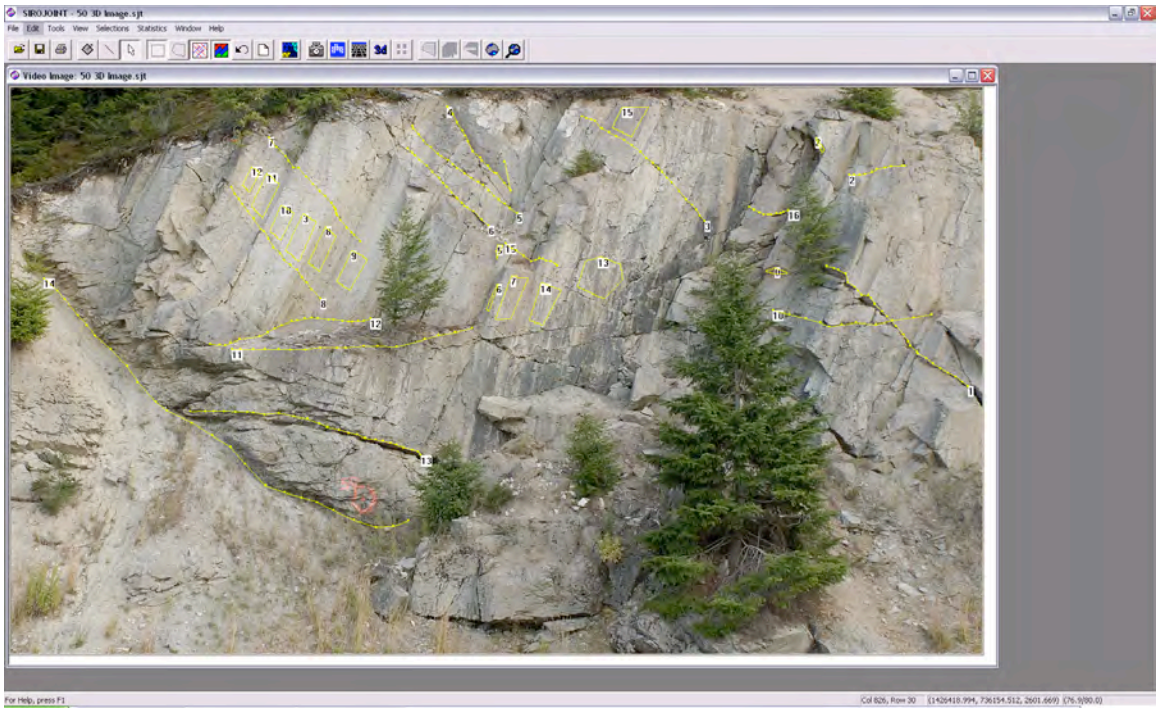
Outcrop model 047



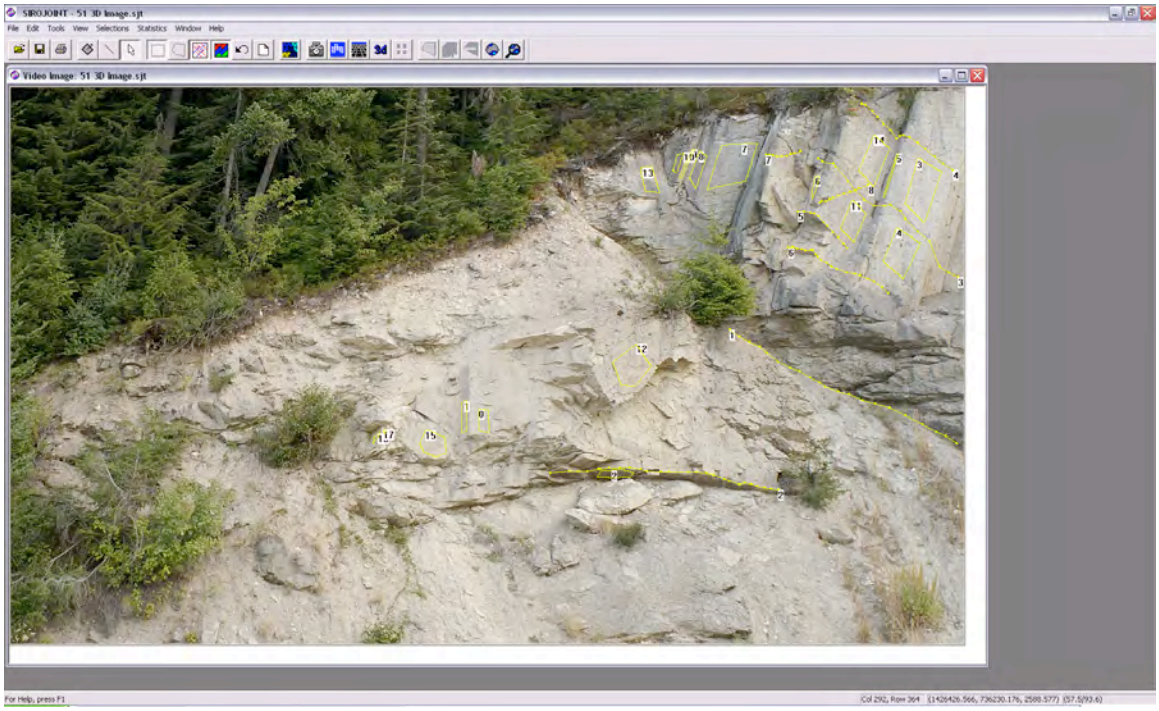
Outcrop model 048



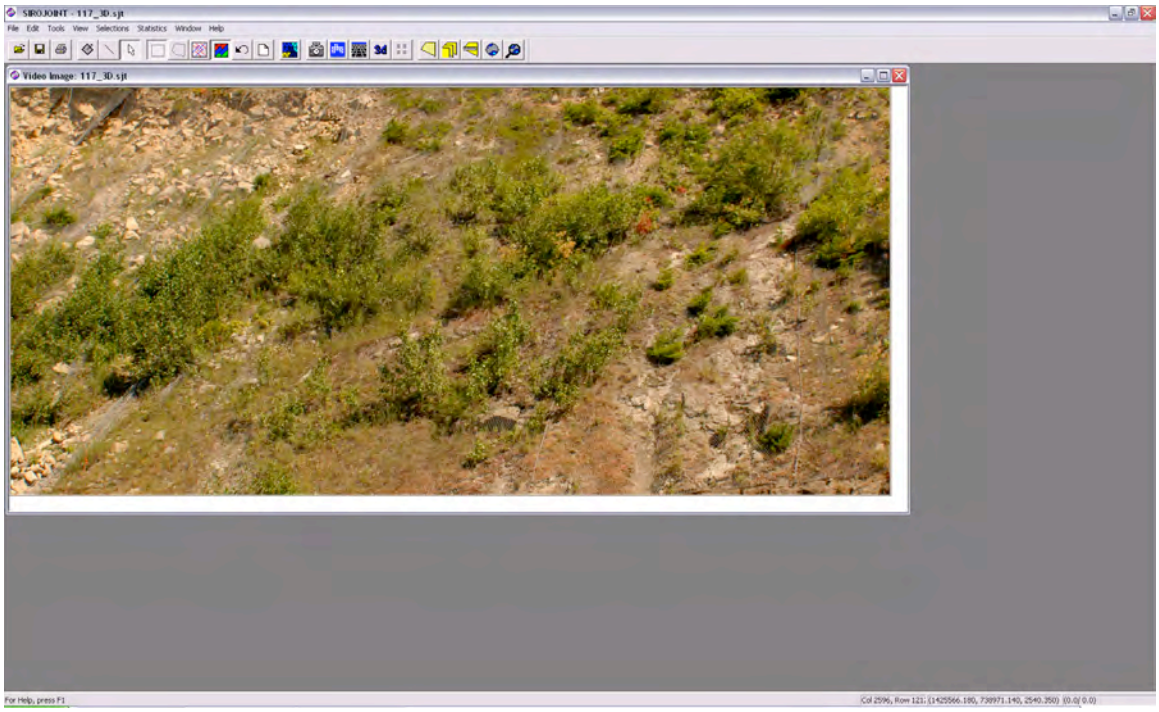
Outcrop model 049



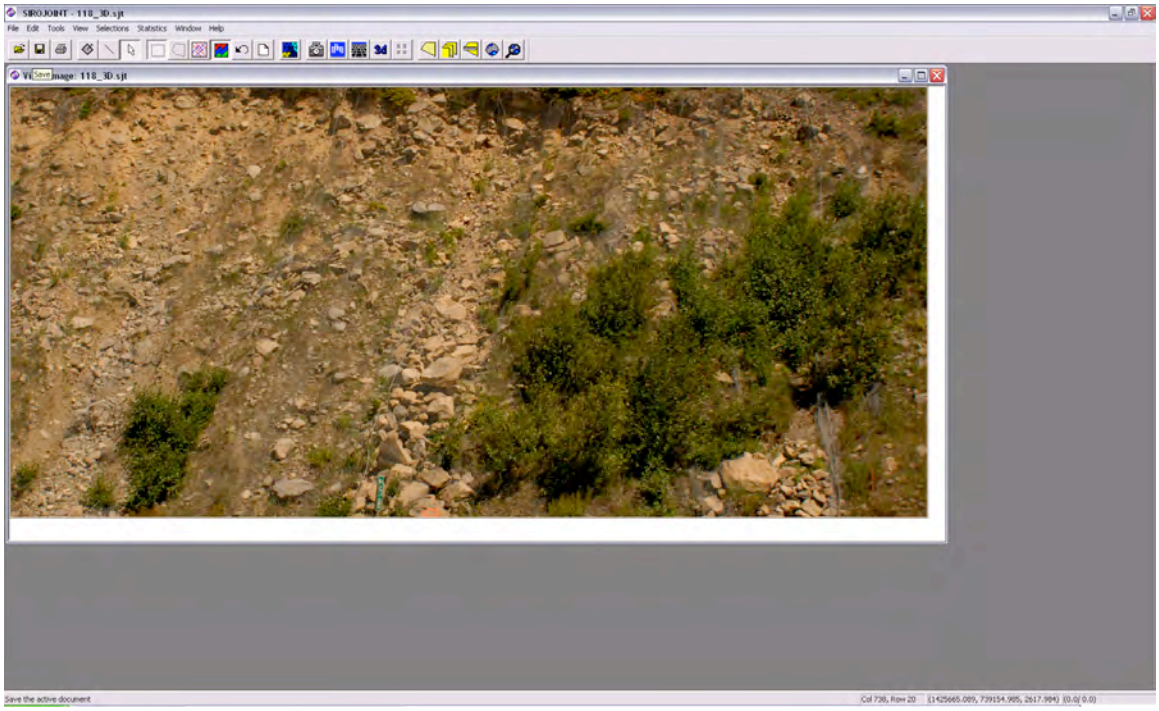
Outcrop model 050



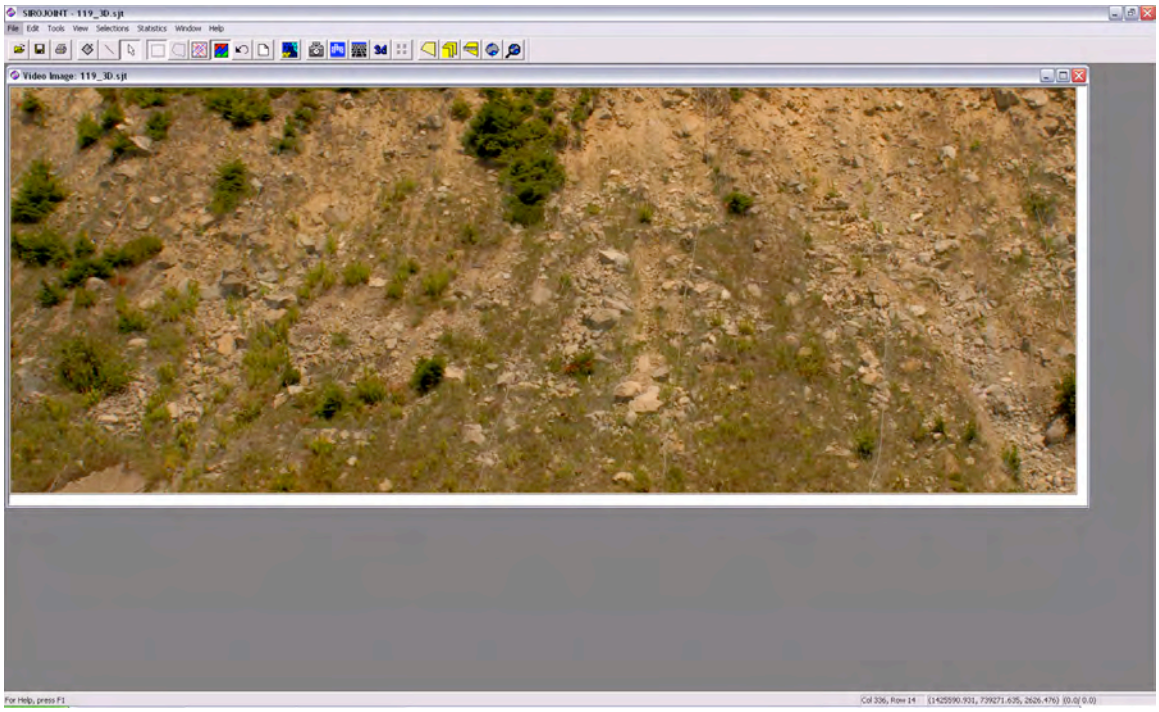
Outcrop model 051



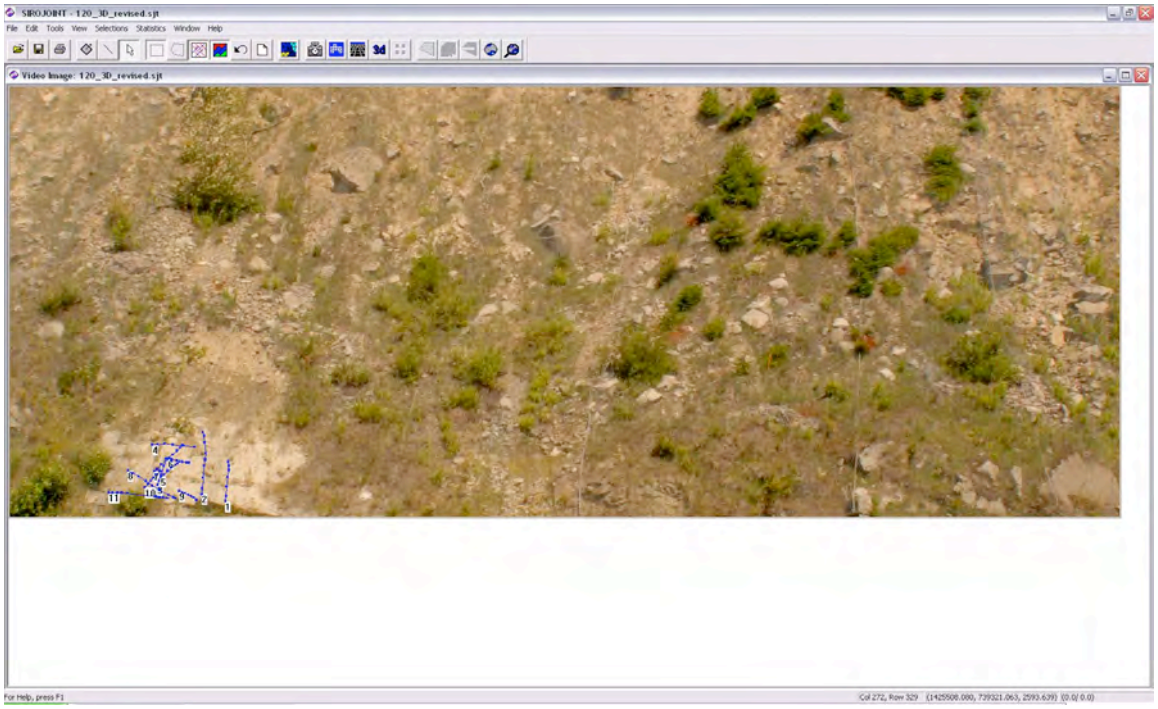
Outcrop model 117



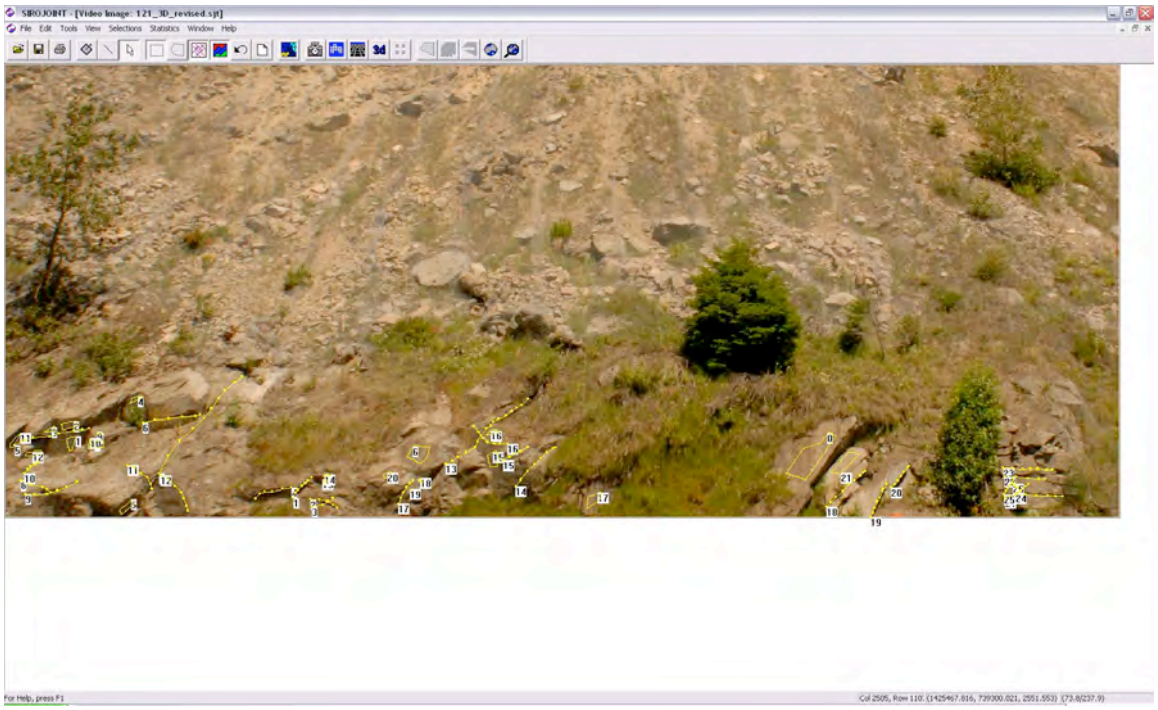
Outcrop model 118



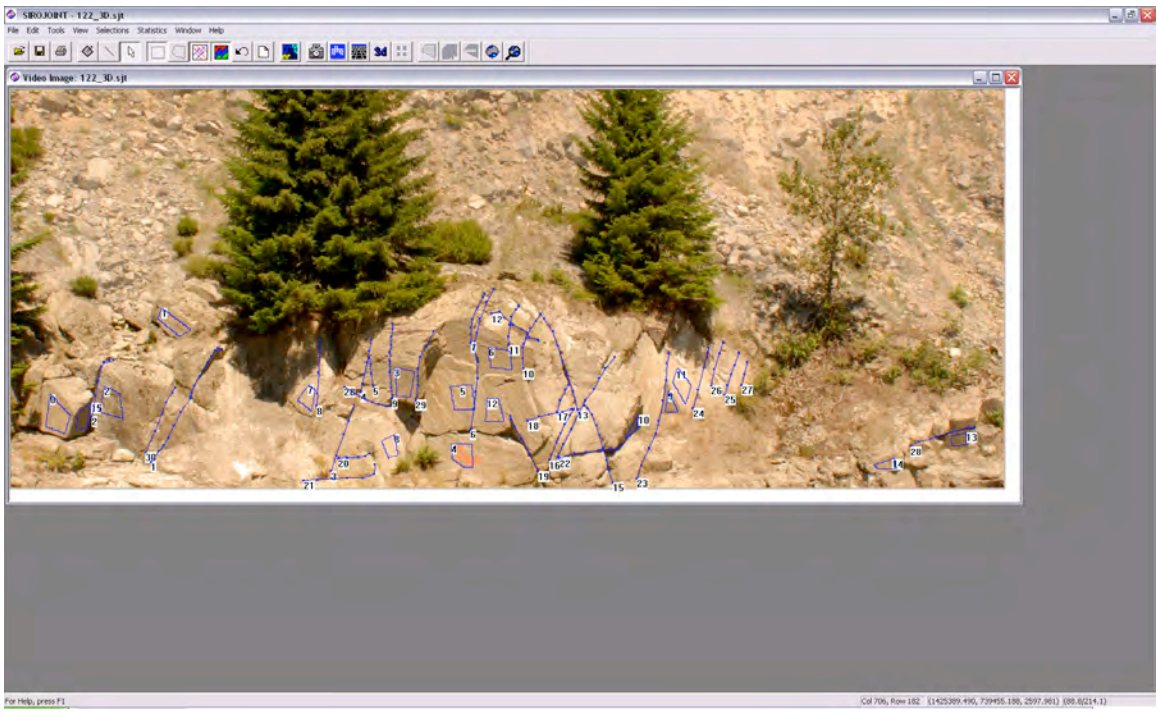
Outcrop model 119



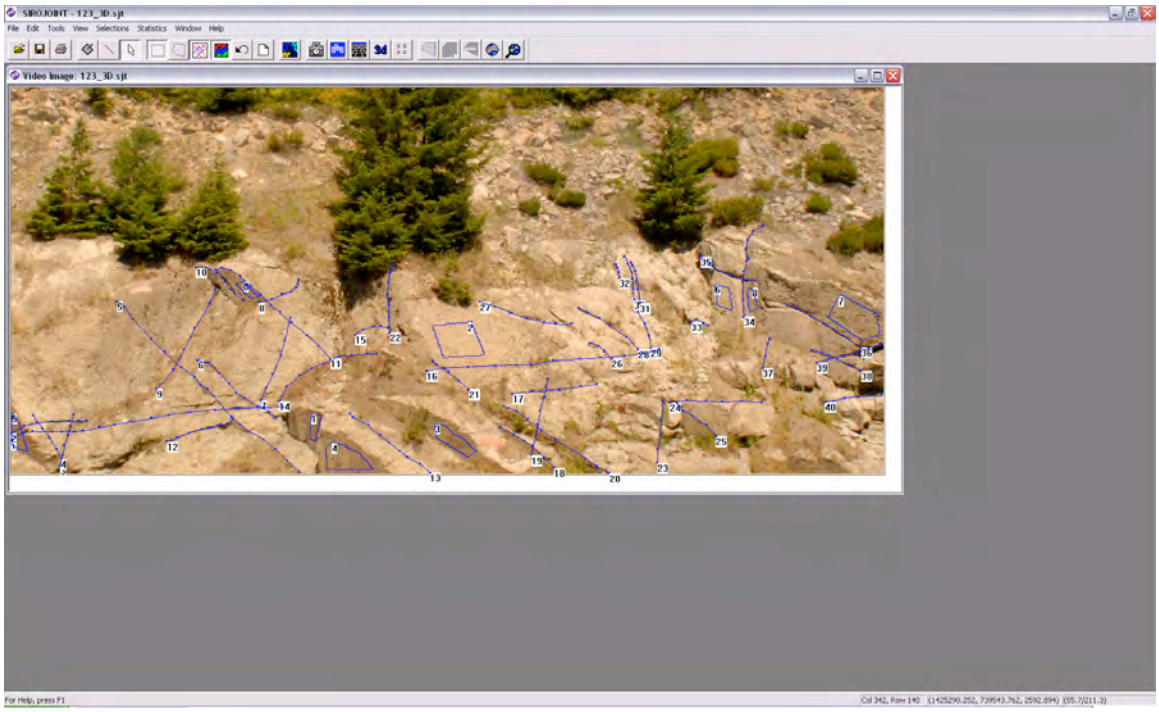
Outcrop model 120 (as revised)



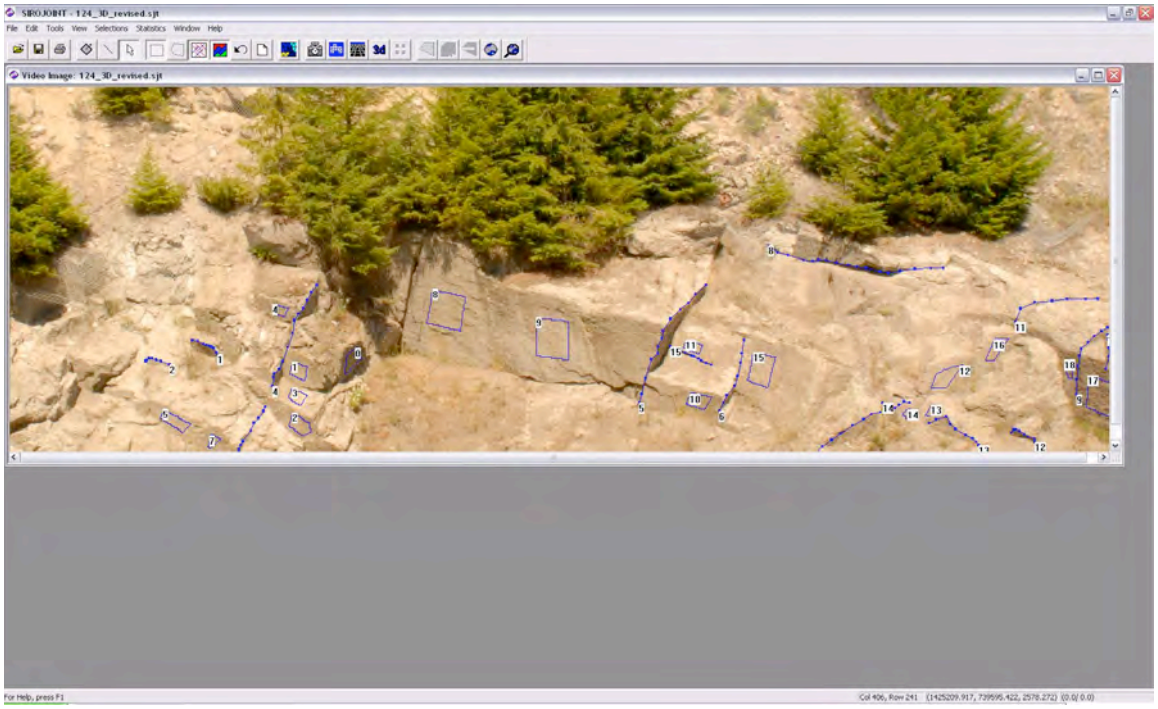
Outcrop model 121 (as revised)



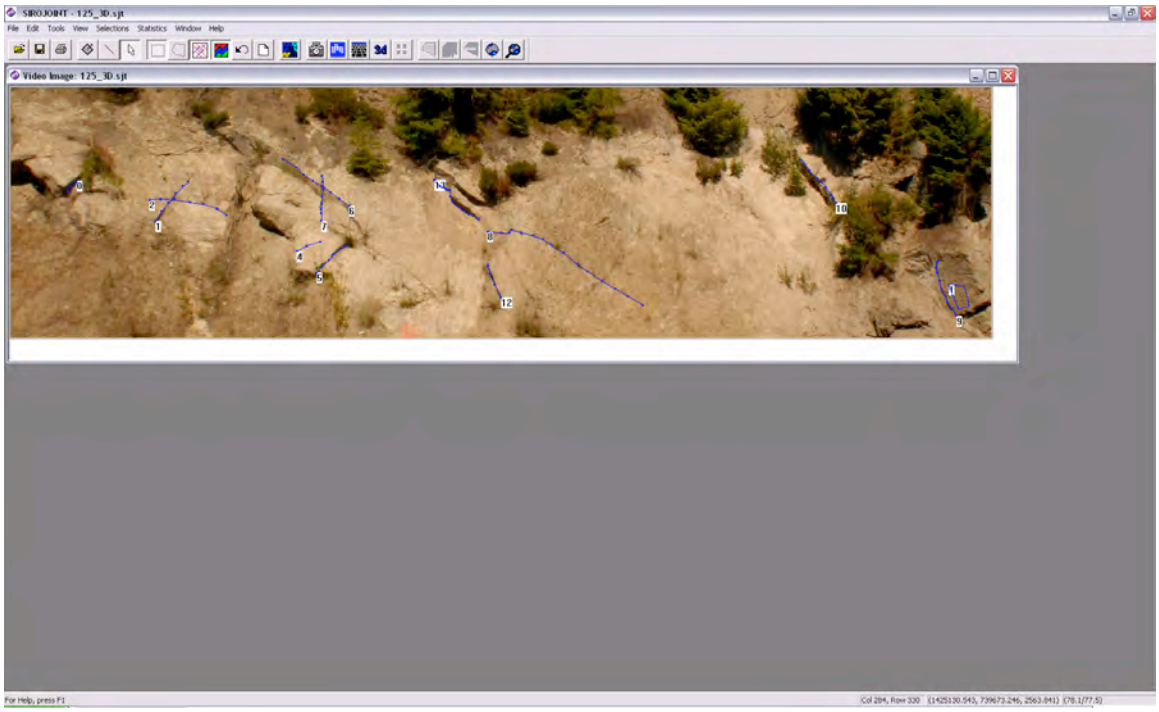
Outcrop model 122



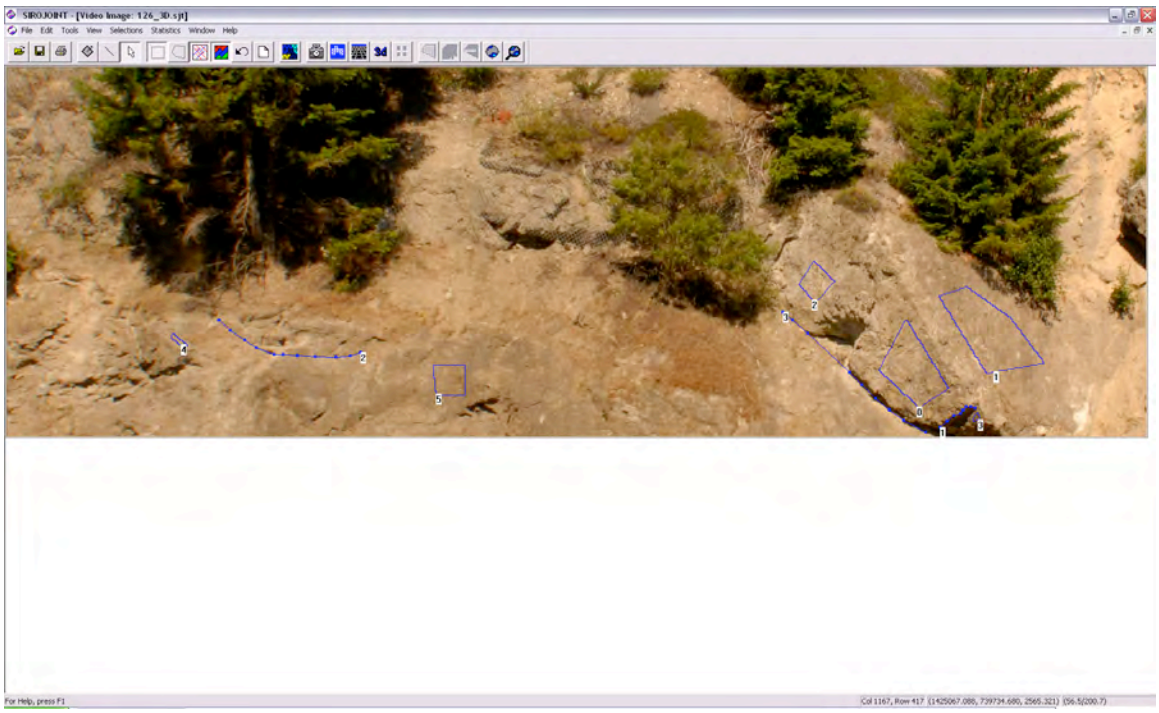
Outcrop model 123



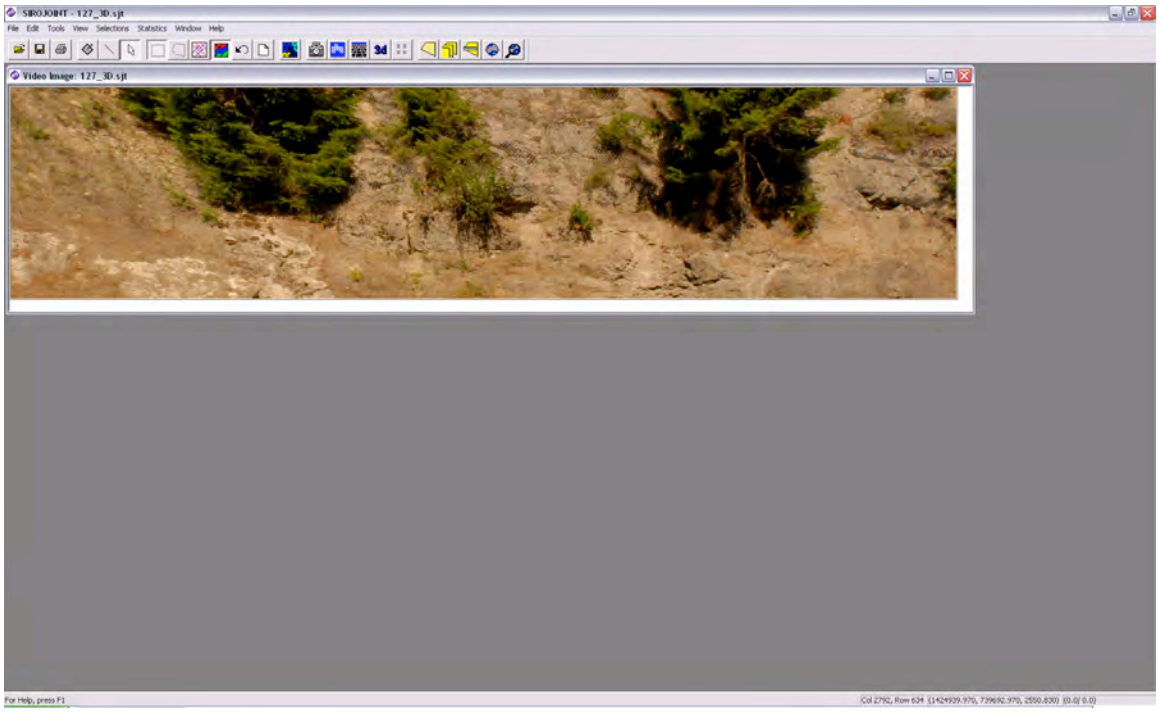
Outcrop model 124 (as revised)



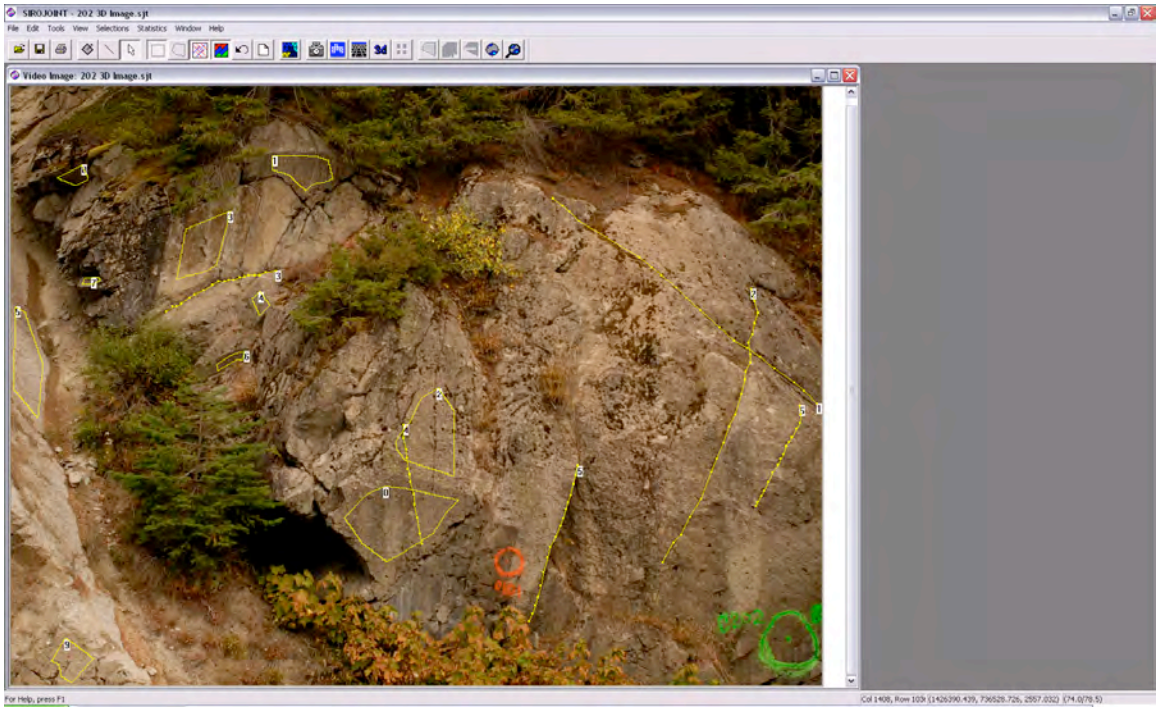
Outcrop model 125



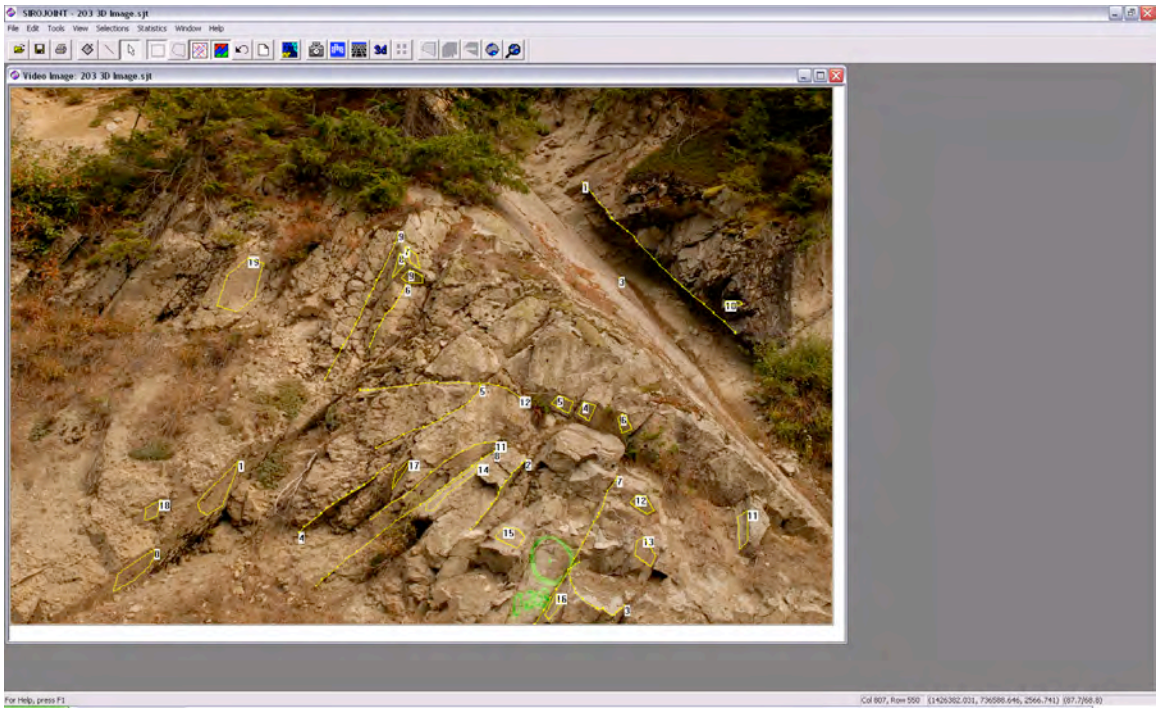
Outcrop model 126



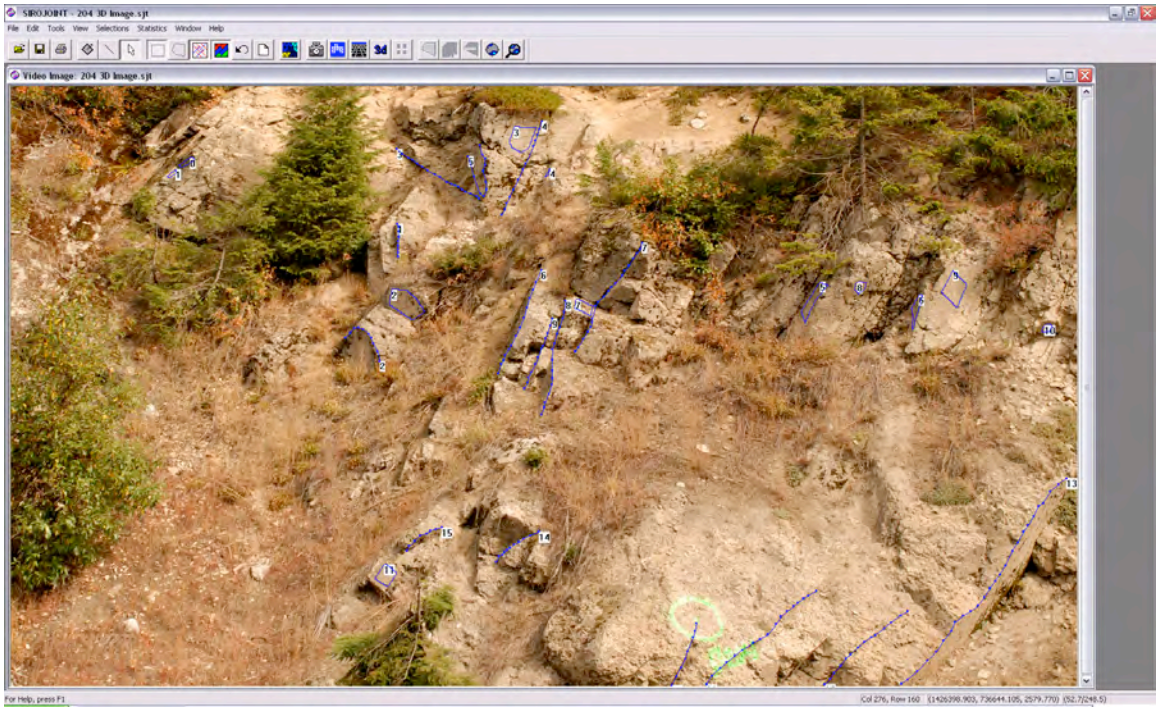
Outcrop model 127



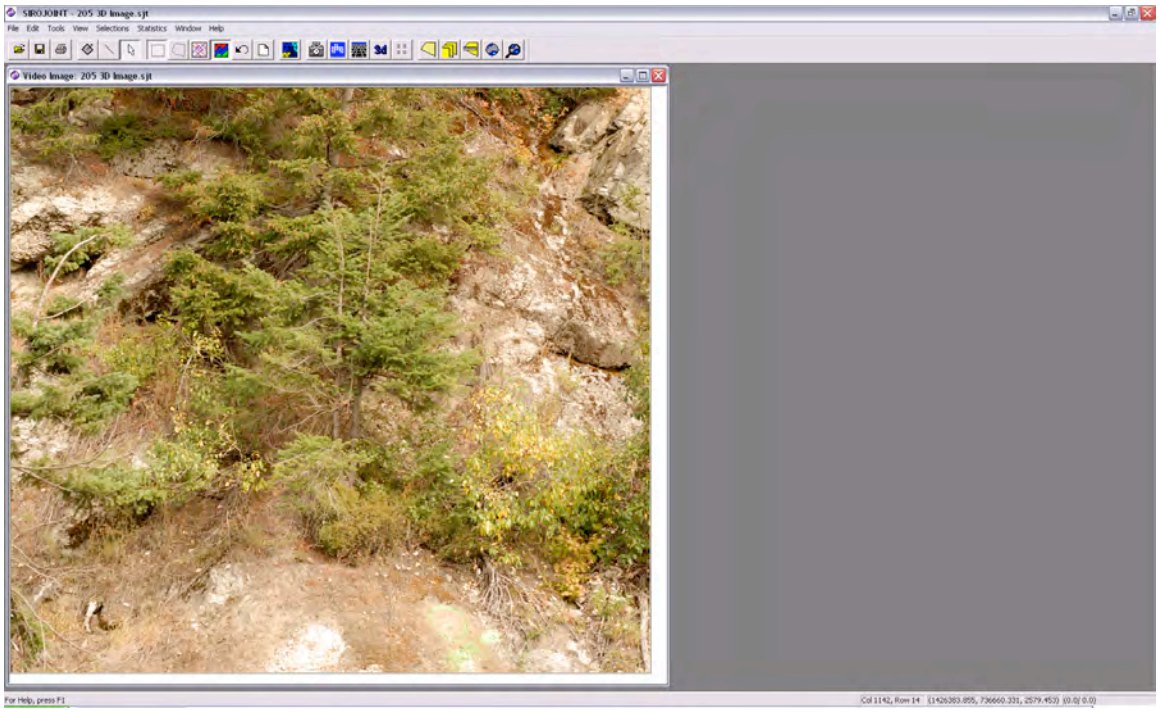
Outcrop model 202



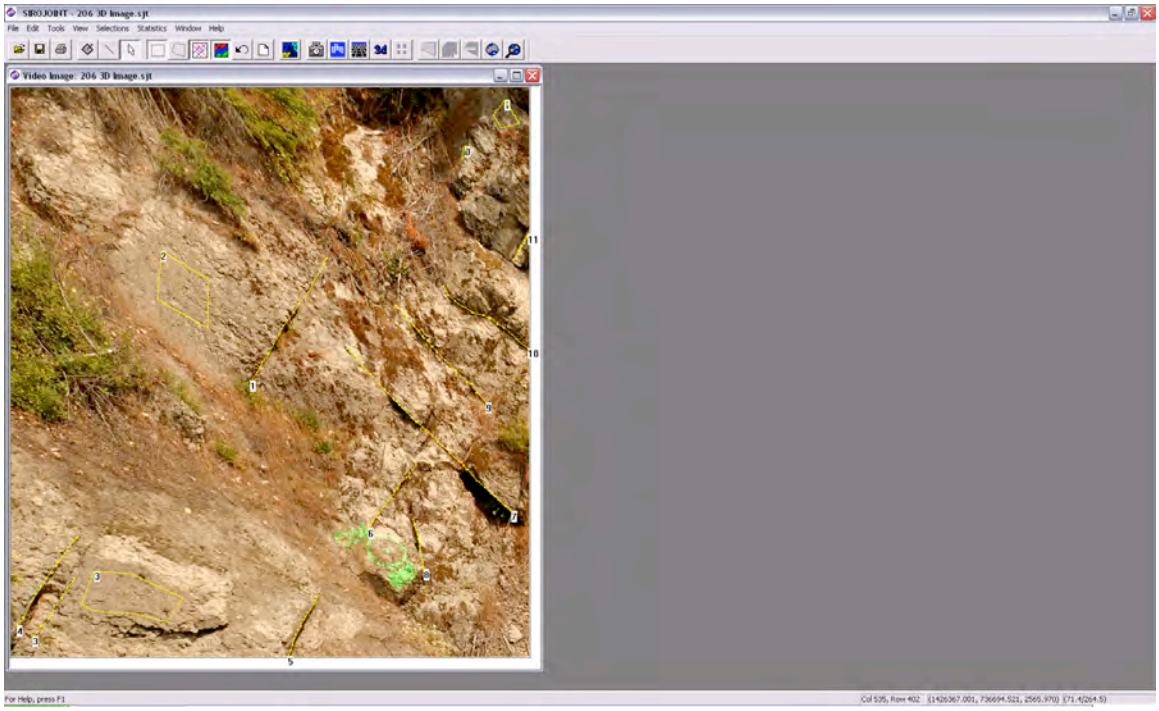
Outcrop model 203



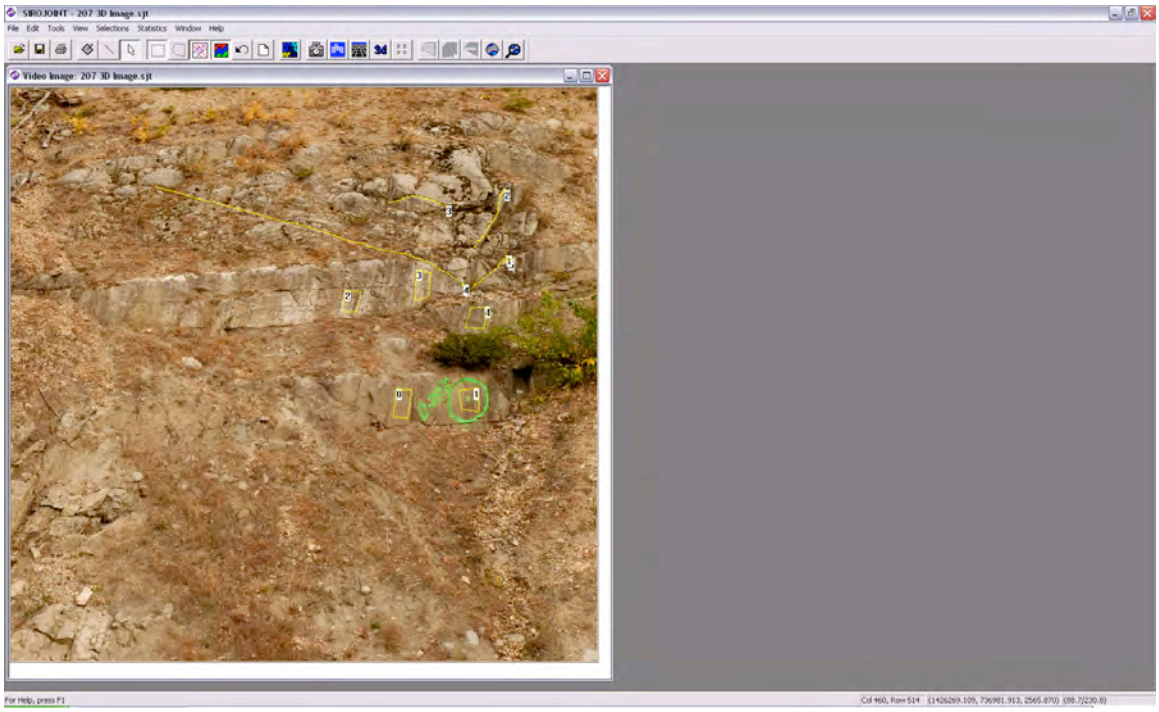
Outcrop model 204



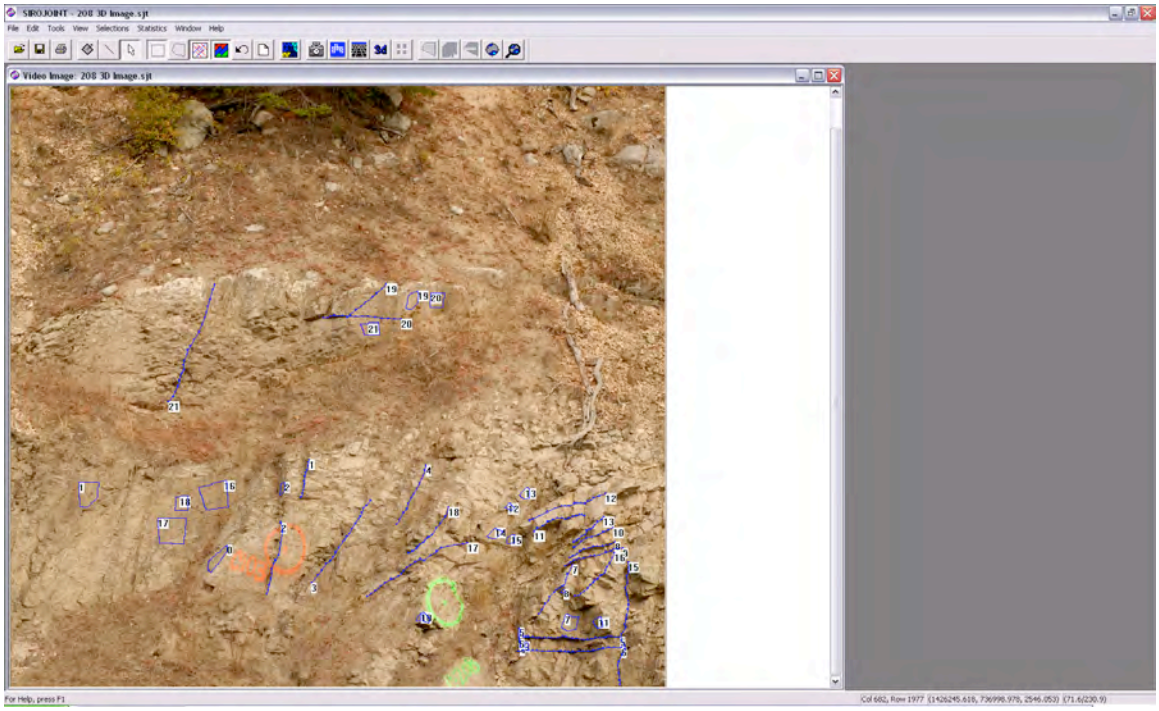
Outcrop model 205



Outcrop model 206



Outcrop model 207



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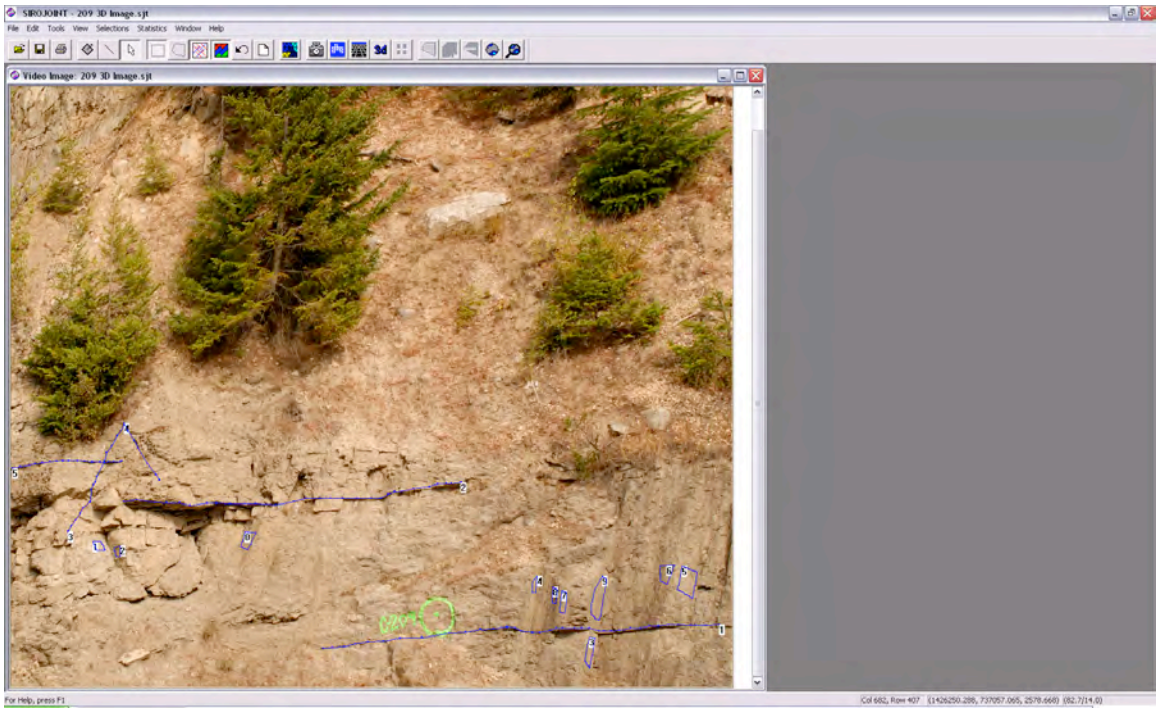
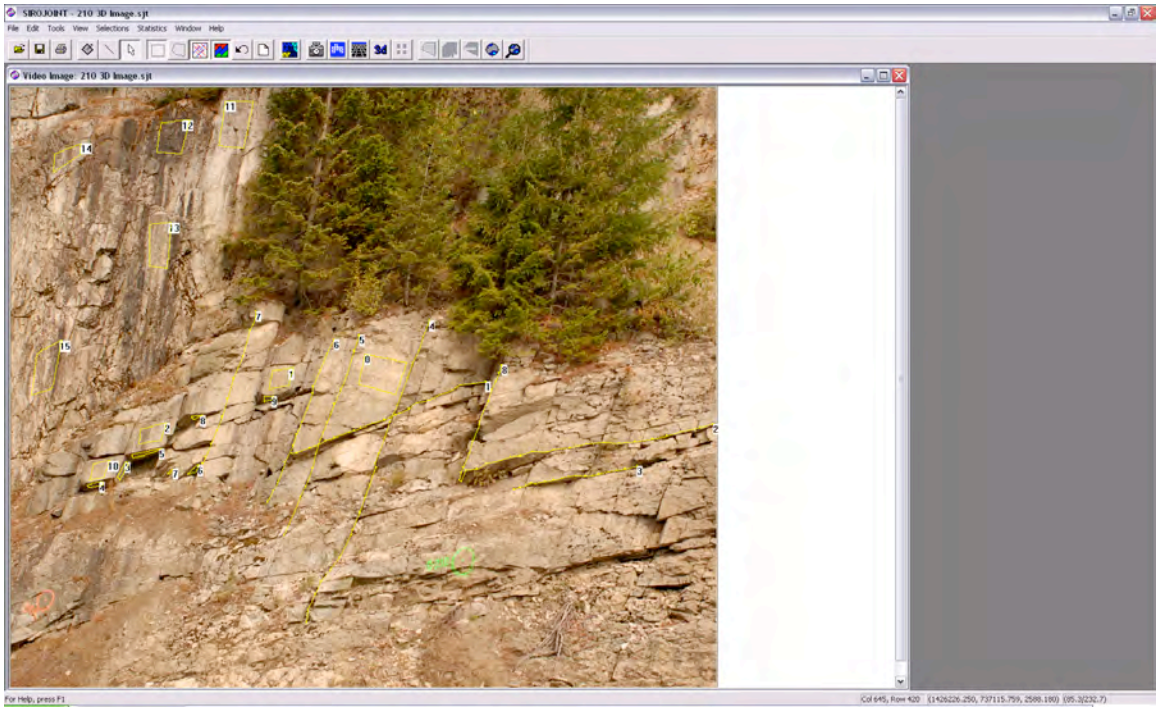
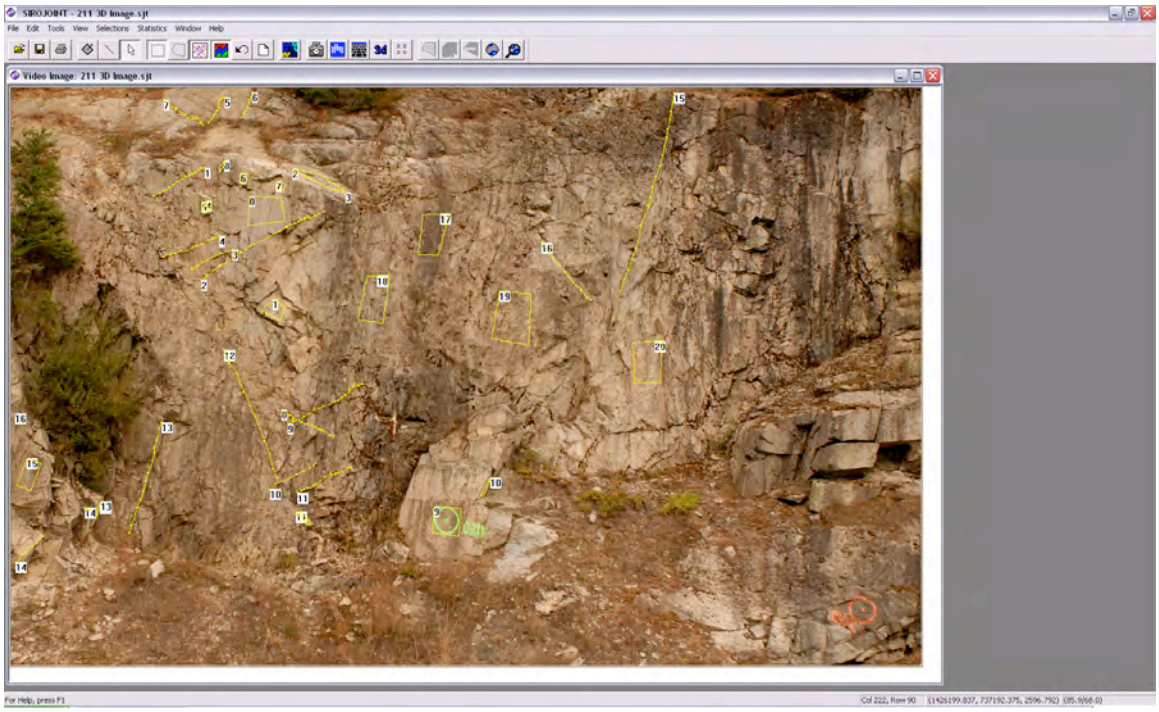


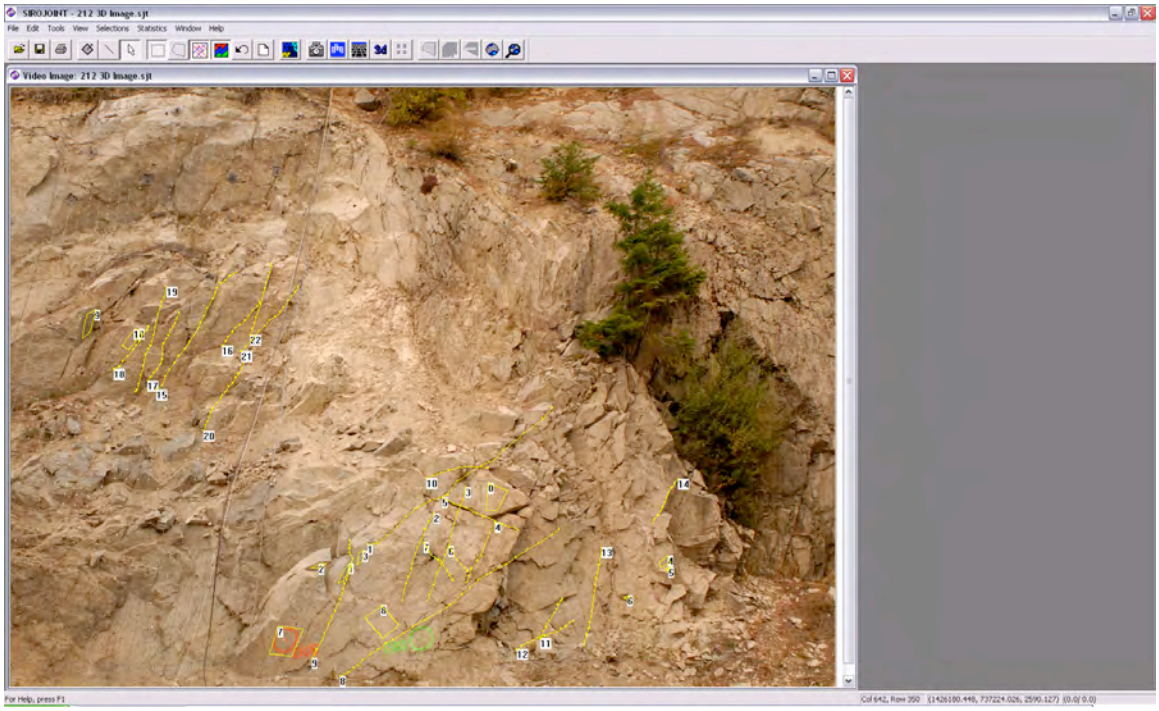
Outcrop model 209



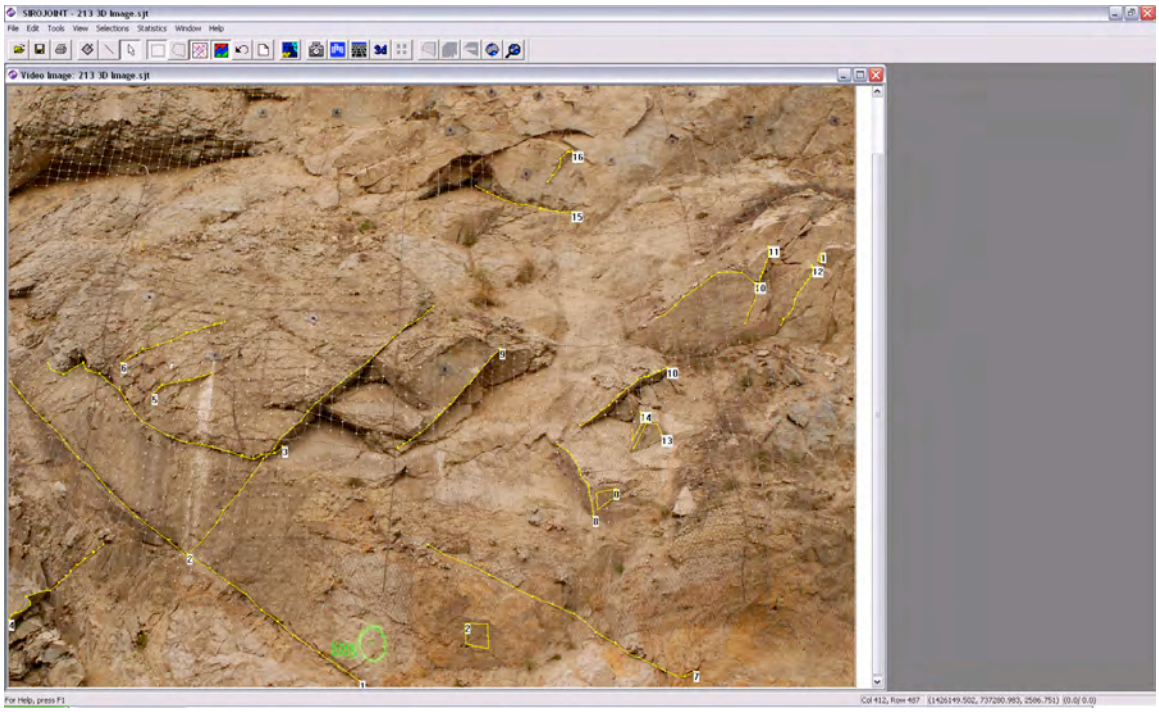
Outcrop model 210



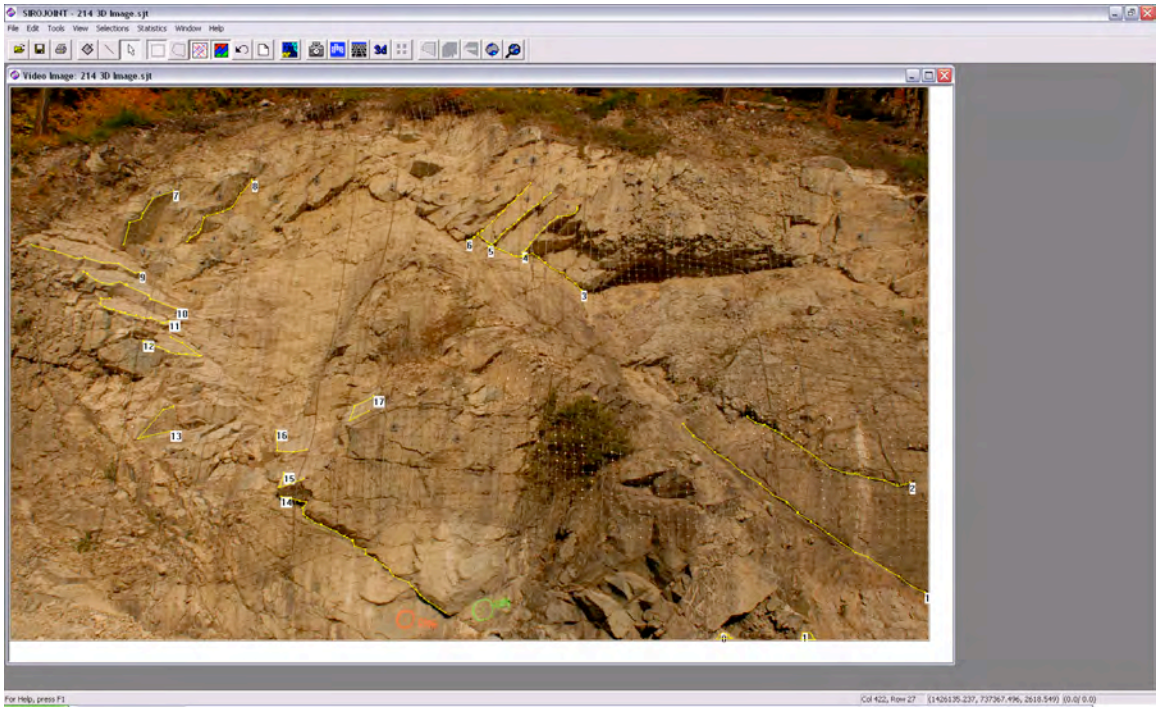
Outcrop model 211



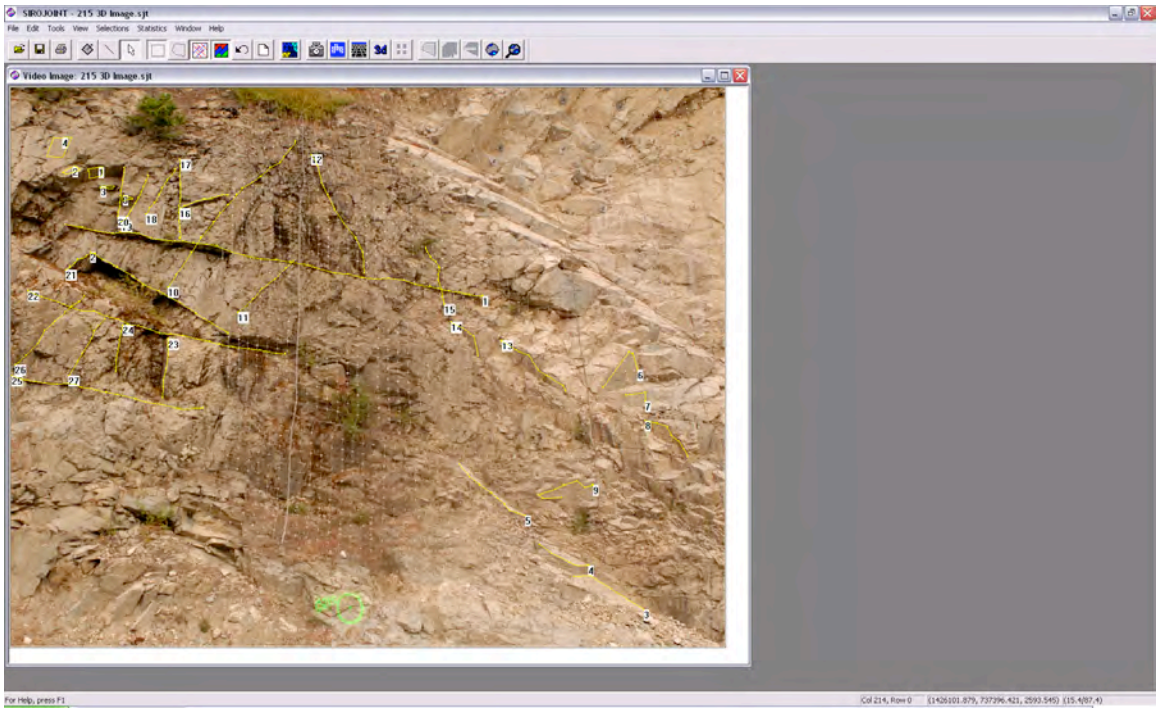
Outcrop model 212



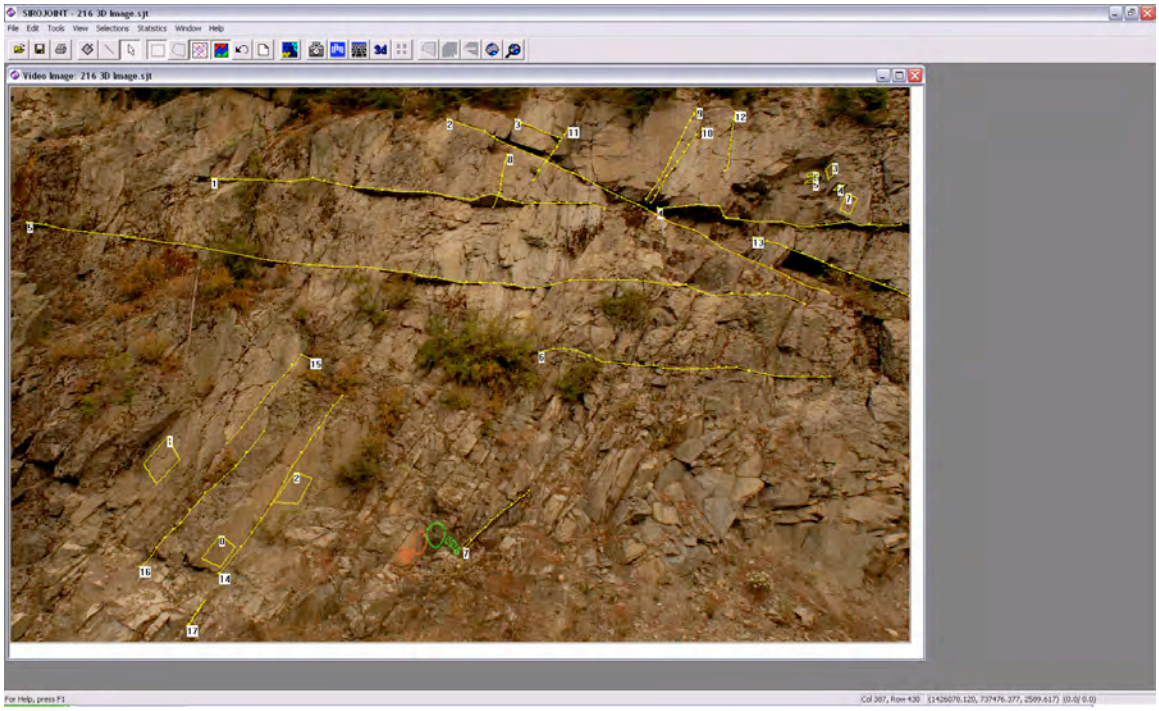
Outcrop model 213



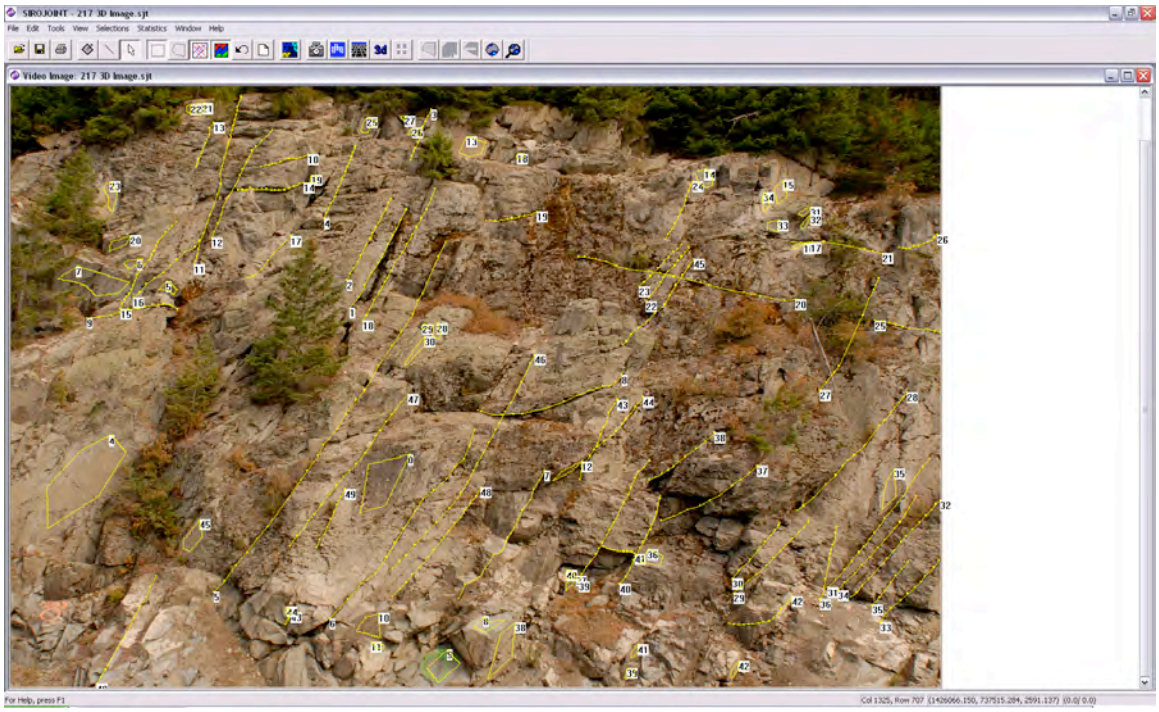
Outcrop model 214



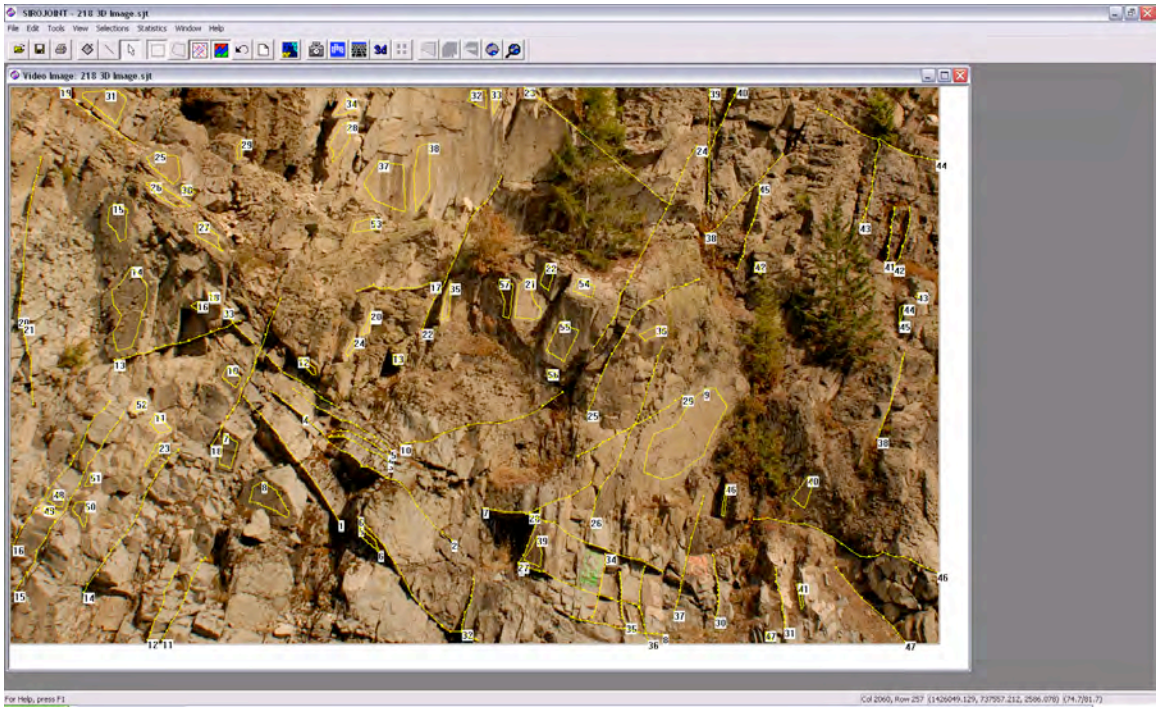
Outcrop model 215



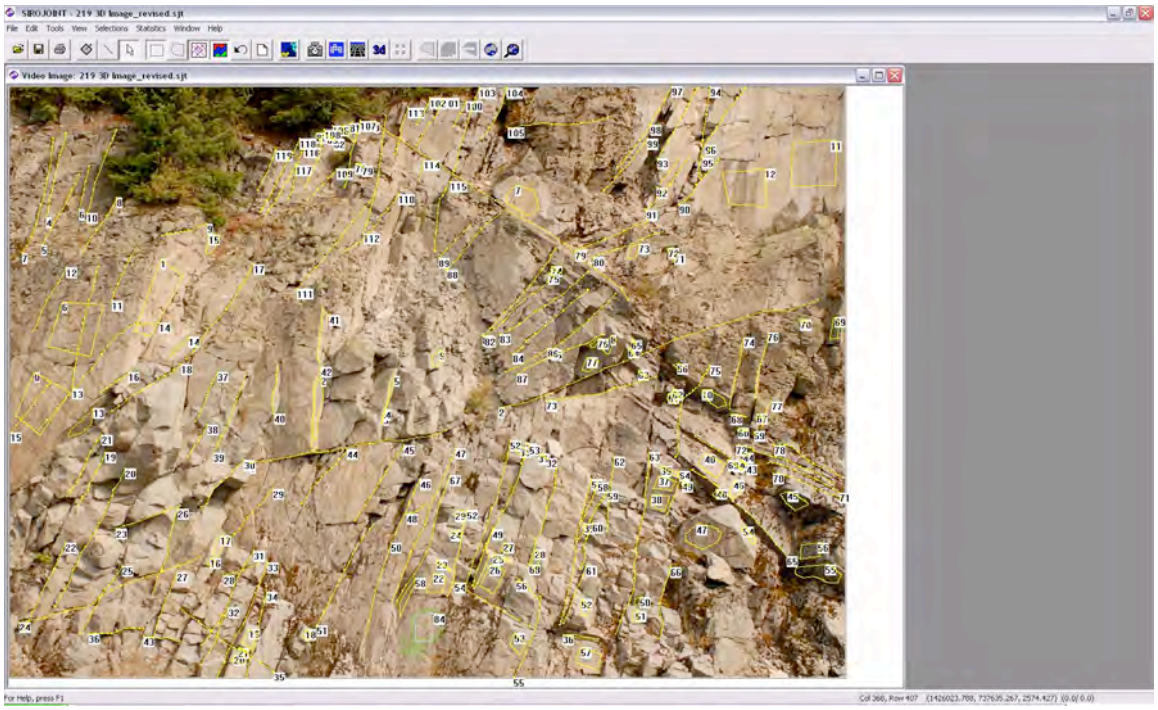
Outcrop model 216



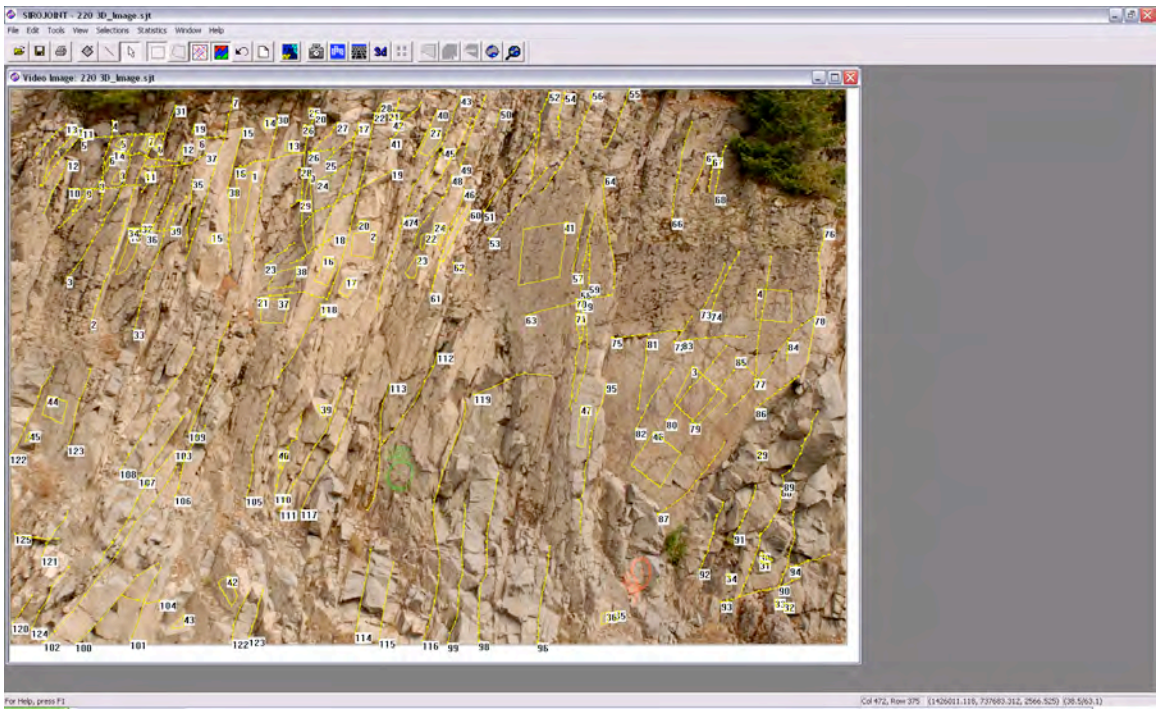
Outcrop model 217



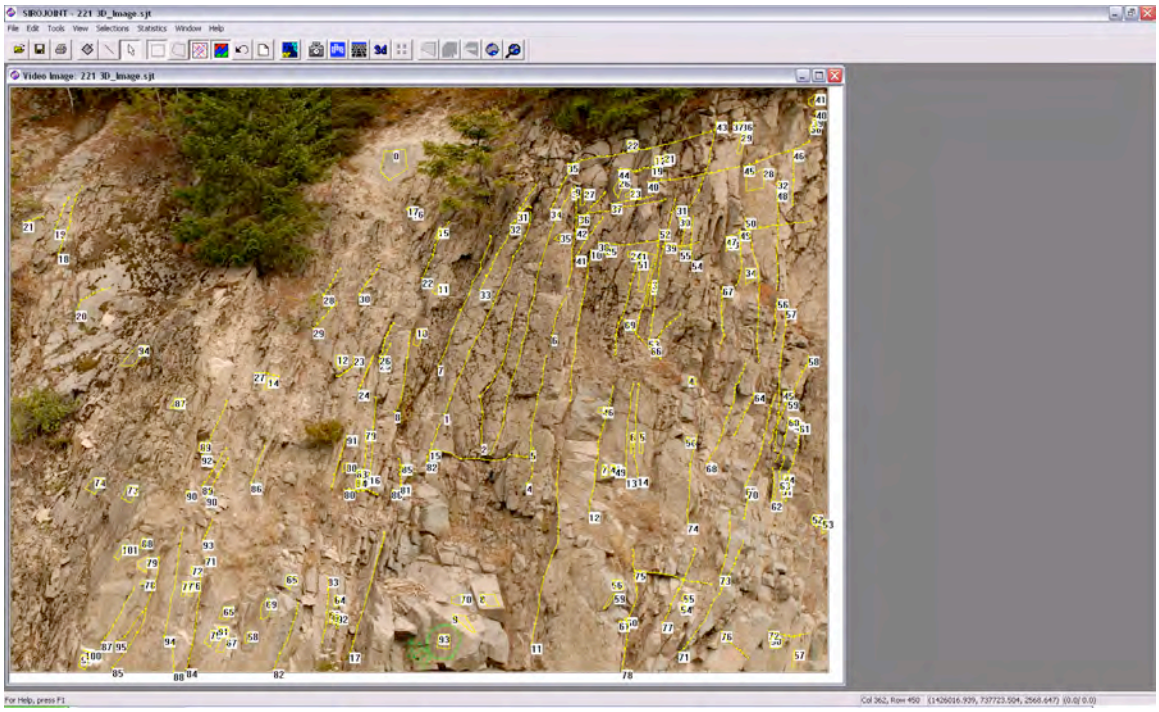
Outcrop model 218



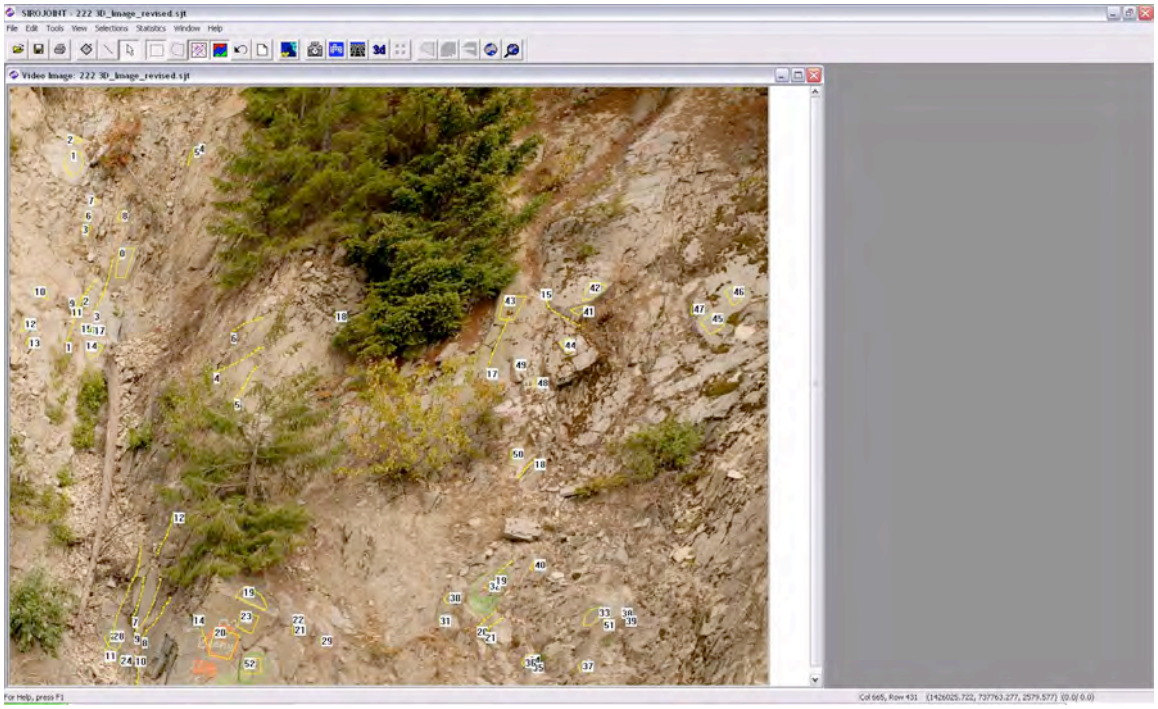
Outcrop model 219 (as revised)



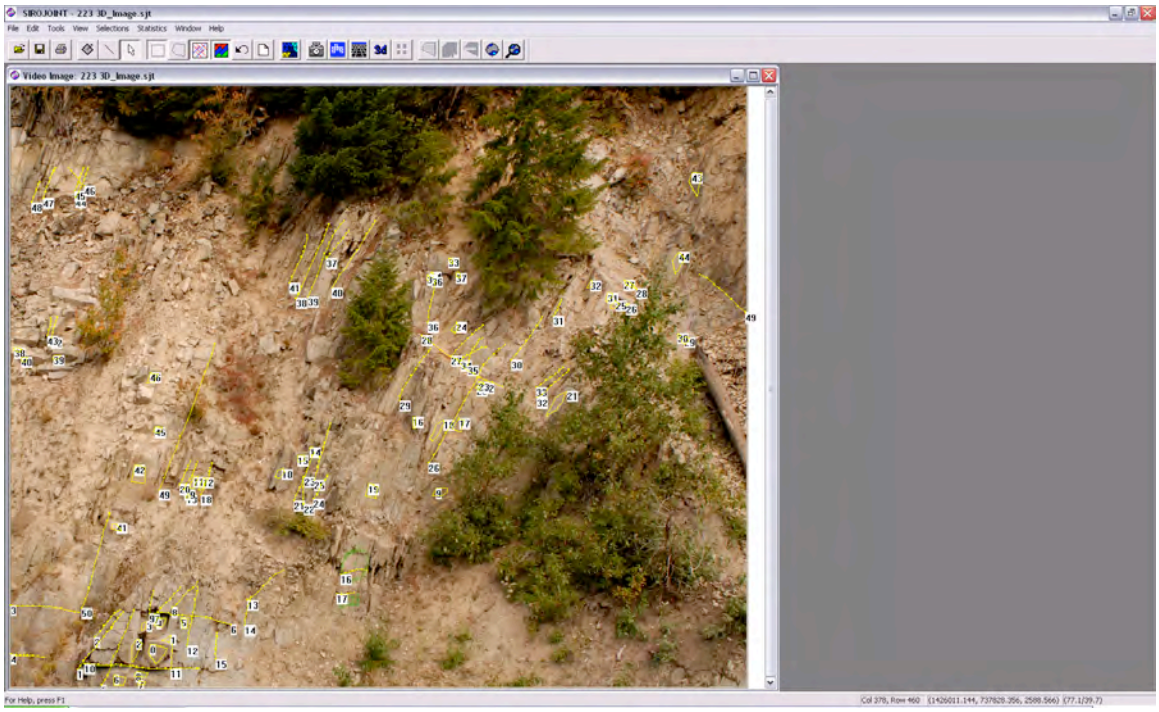
Outcrop model 220



Outcrop model 221

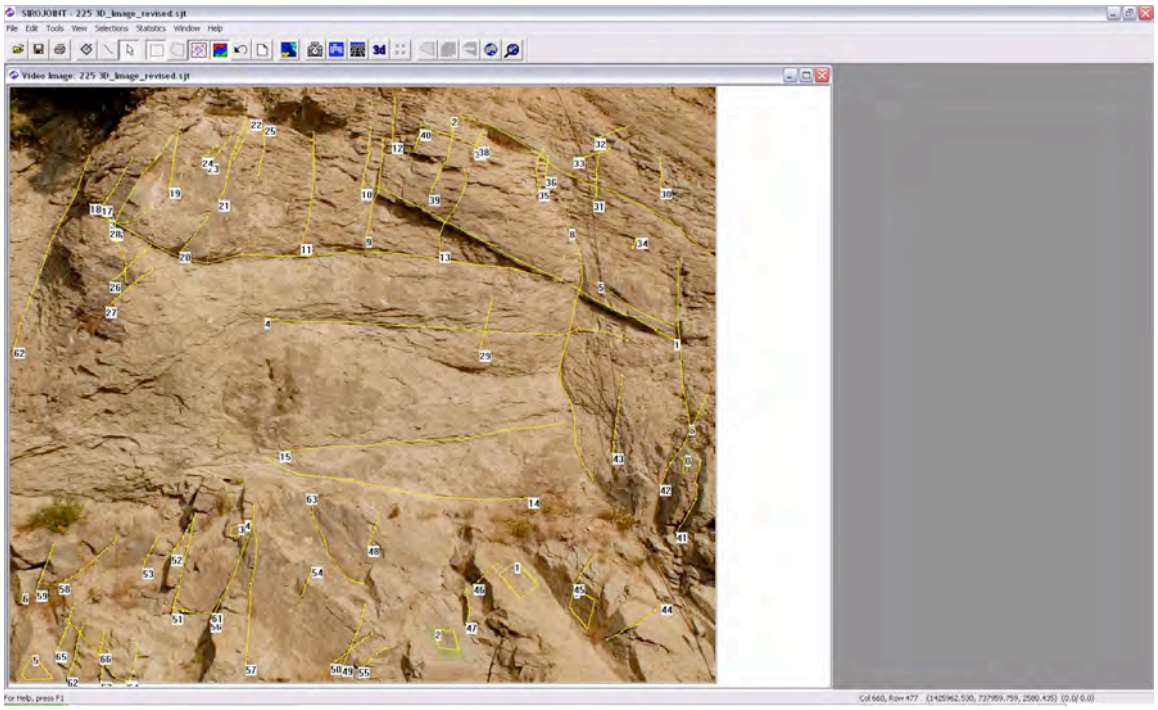


Outcrop model 222 (as revised)

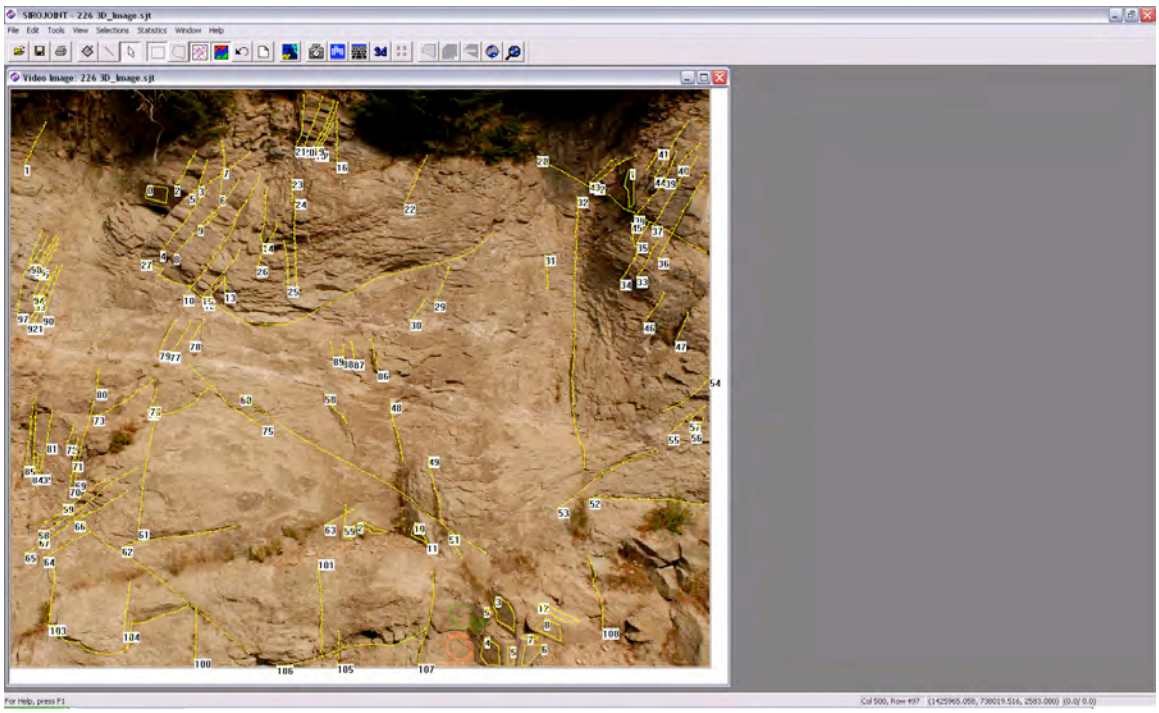


Outcrop model 223

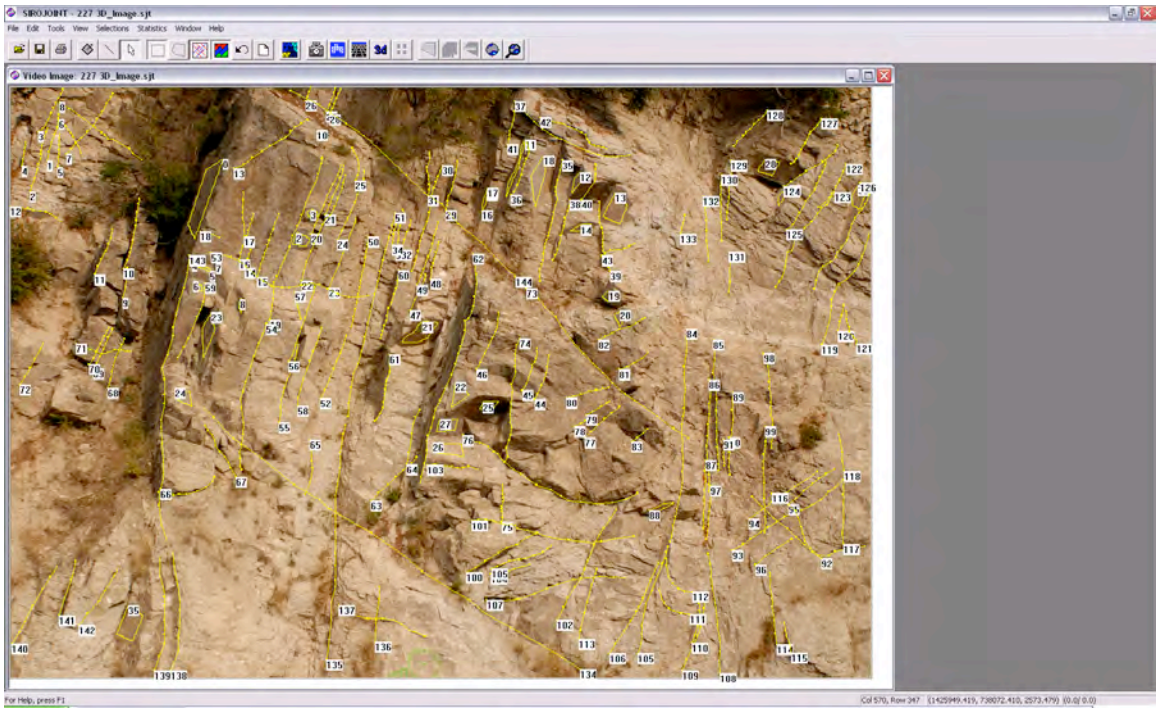
Outcrop model 224 (as revised)



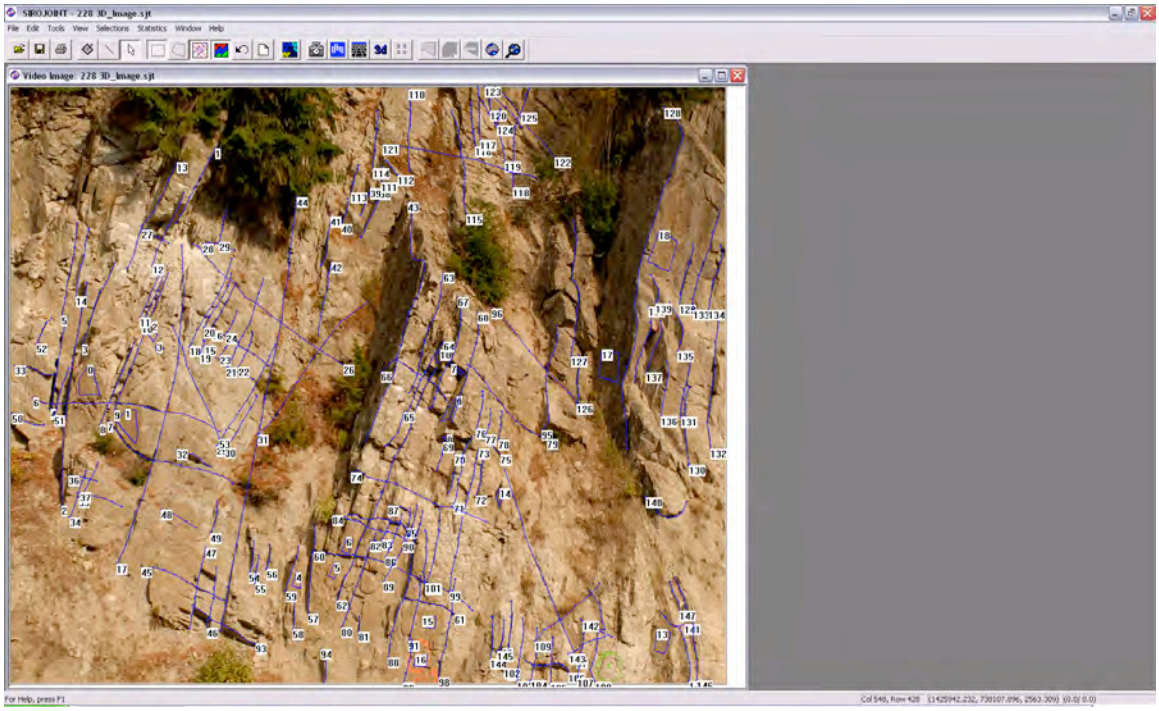
Outcrop model 225 (as revised)



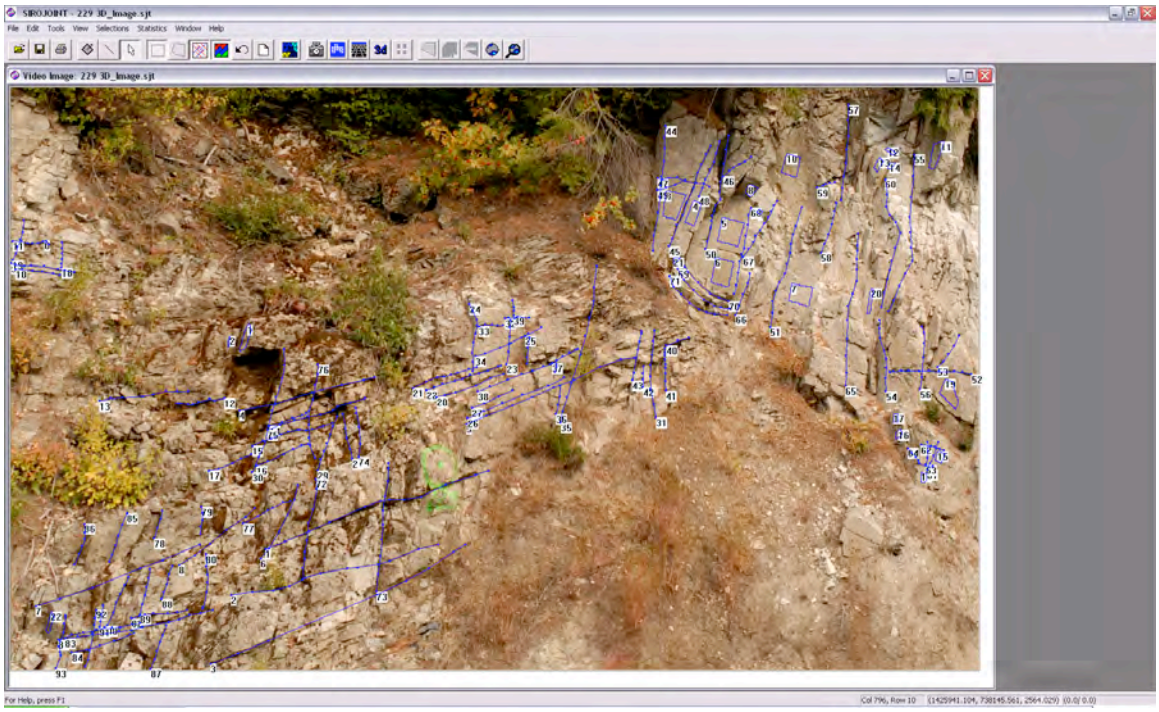
Outcrop model 226



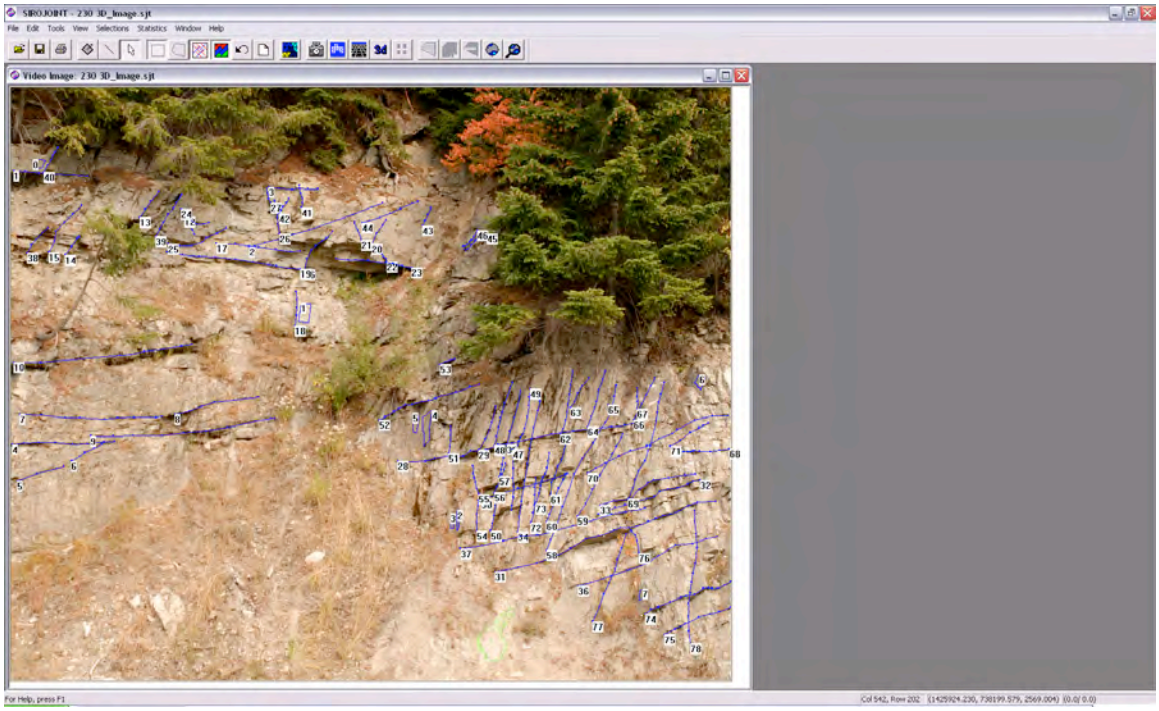
Outcrop model 227



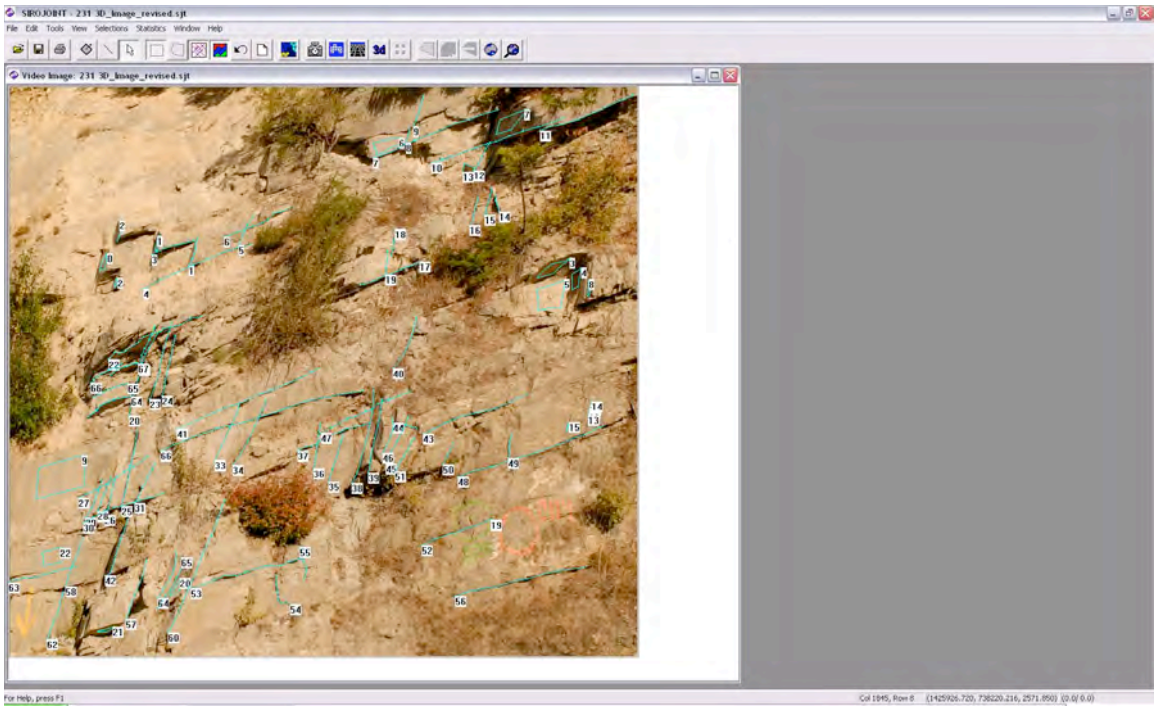
Outcrop model 228



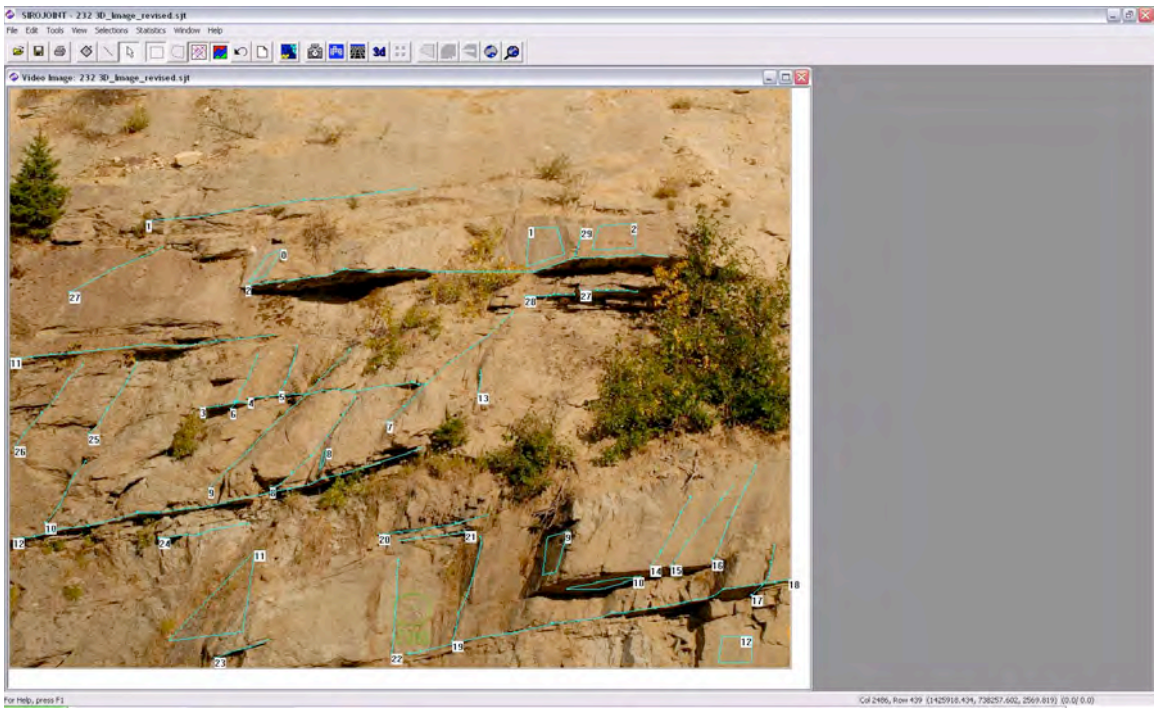
Outcrop model 229



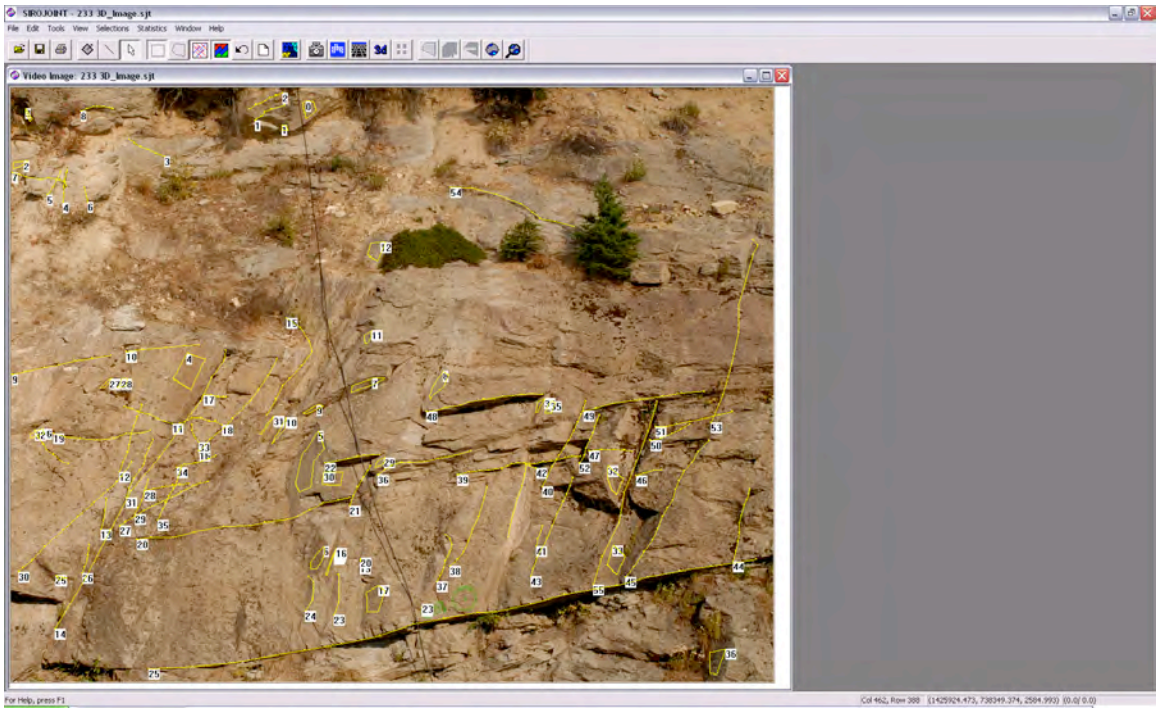
Outcrop model 230



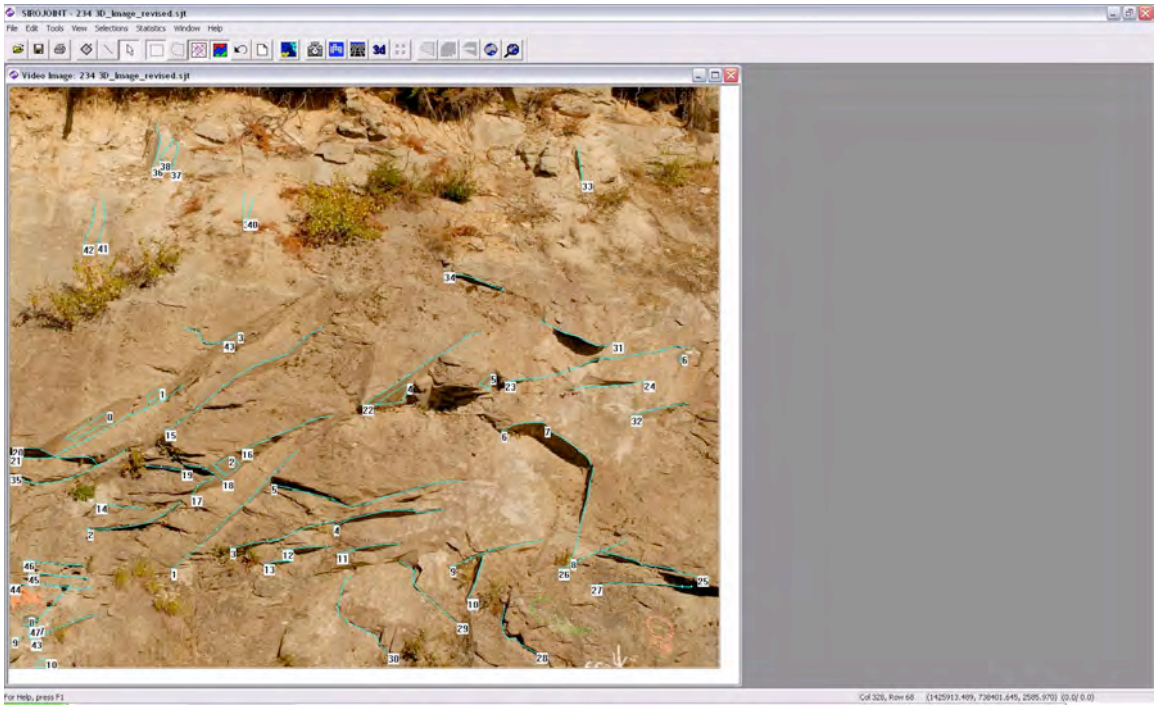
Outcrop model 231 (as revised)



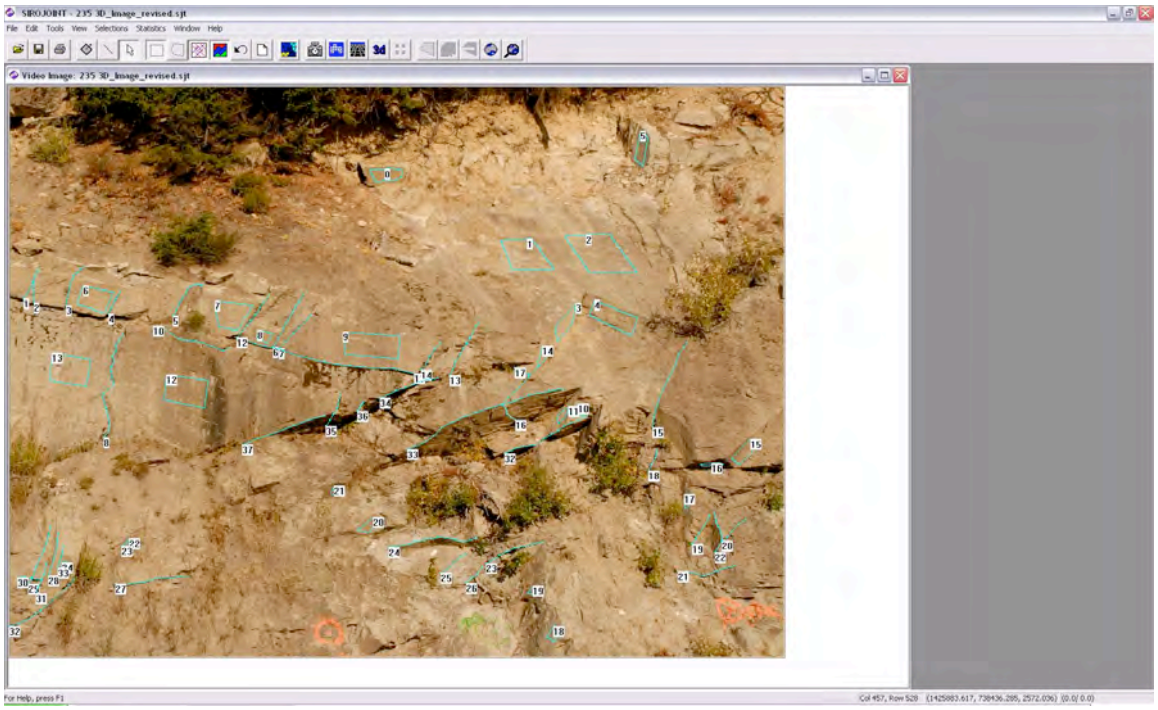
Outcrop model 232 (as revised)



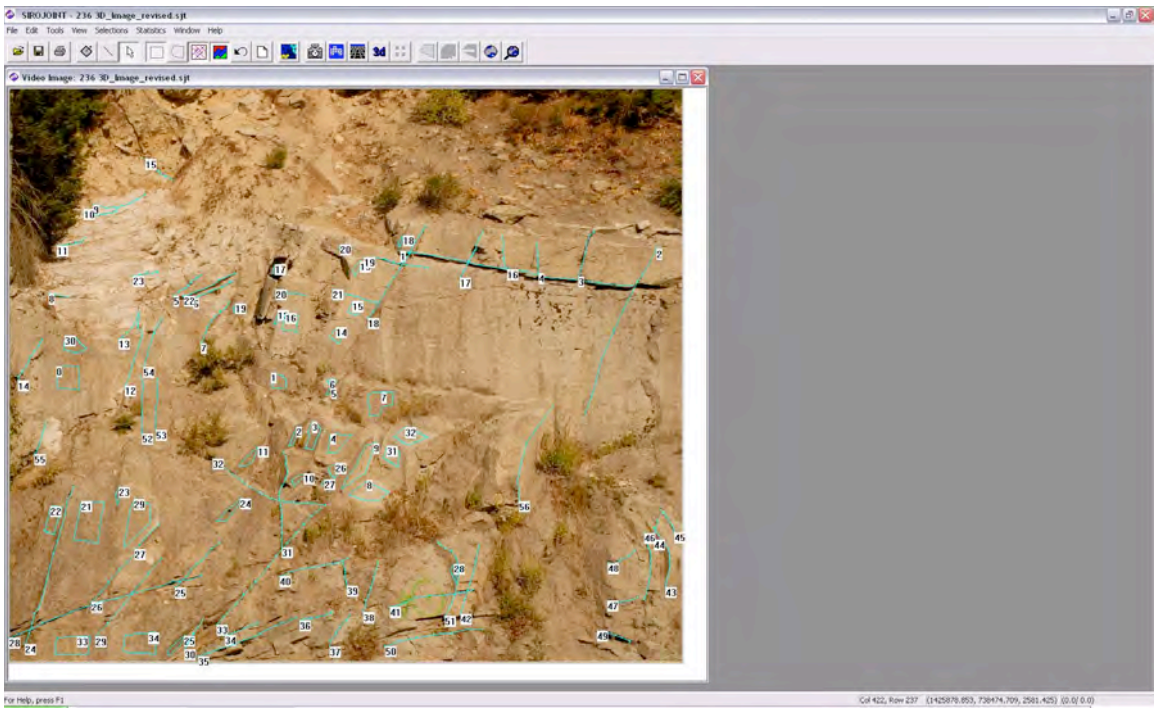
Outcrop model 233



Outcrop model 234 (as revised)



Outcrop model 235 (as revised)



Outcrop model 236 (as revised)

Best-fit plane and structural orientation for point measurements supplied by Balin Strickler

Bill Haneberg
12/02/07
Mathematica 6.0 Notebook

Best-fit plane using all values

Enter the coordinates as three separate vectors, then find their minima and maxima (which will help to scale the data and resulting plots)

In[1]:=
```
data = Import["/Users/bill/Documents/I-90 Sirovision 2007/overhang_2.dat"]
```

Out[1]=
```
{{737314., 1.42626×10^6, 2695.74},
 {737321., 1.42626×10^6, 2703.46}, {737319., 1.42626×10^6, 2701.56},
 {737331., 1.42627×10^6, 2714.13}, {737324., 1.42627×10^6, 2710.54},
 {737343., 1.42627×10^6, 2725.75}, {737338., 1.42628×10^6, 2726.41},
 {737350., 1.42628×10^6, 2736.71}, {737347., 1.42628×10^6, 2733.73}}
```

In[2]:=
```
northings = Table[data[[i, 1]], {i, Length[data]}];
eastings = Table[data[[i, 2]], {i, Length[data]}];
elevations = Table[data[[i, 3]], {i, Length[data]}];
```

In[5]:=
```
minx = Min[eastings]
```

Out[5]= 1.42626×10^6

In[6]:=
```
maxx = Max[eastings]
```

Out[6]= 1.42628×10^6

In[7]:=
```
miny = Min[northings]
```

Out[7]= 737314.

In[8]:=
```
maxy = Max[northings]
```

Out[8]= 737350.

In[9]:=
```
minz = Min[elevations]
```

Out[9]= 2695.74

In[10]:=
```
maxz = Max[elevations]
```

Out[10]= 2736.71

In[11]:=
```
npts = 7;
```

Organize the points into *xyz* triplets, subtracting the minimum easting and northing to re-scale the coordinates for better results. The magnitudes of the elevations are reasonable, so do not re-scale them.

In[12]:=
```
pts = Table[{eastings[[i]] - minx, northings[[i]] - miny, elevations[[i]]}, {i, npts}];
```

Fit the points to a plane with the equation $z = a + bx + cy$

In[13]:=
```
Clear[x, y]
```

In[14]:=
```
bestfitplane7 = Fit[pts, {1, x, y}, {x, y}]
```

Out[14]= 2695.93 + 0.441889 x + 0.791507 y

Now, generate some graphical elements to represent the points, the best-fit plane, and a horizontal reference plane that will be useful for visualizing the strike and dip.

In[15]:=
```
balls = Graphics3D[{RGBColor[1, 0, 0], Table[Sphere[pts[[i]], 0.5], {i, 7}]}, Axes → True];
```

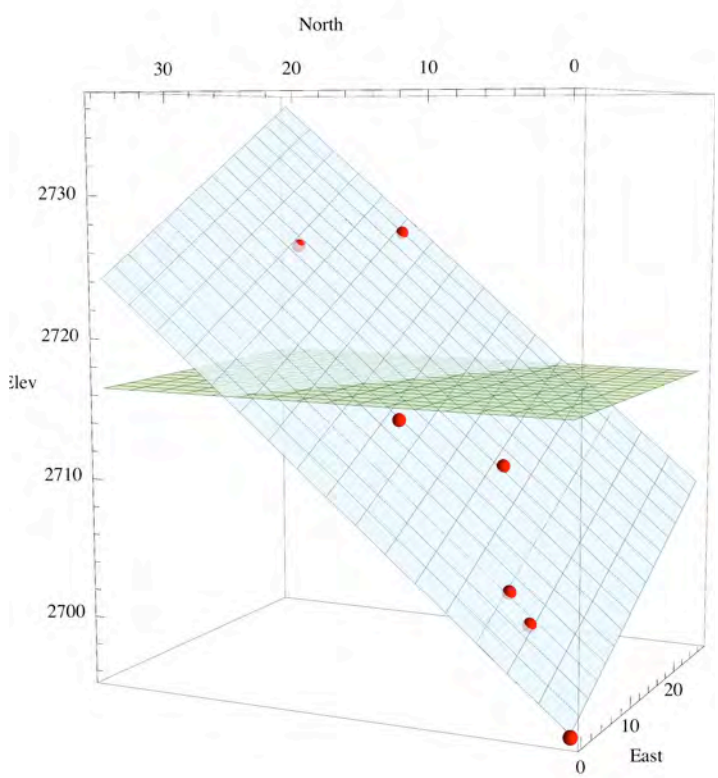
In[16]:=
```
bestfitplot7 =
  Plot3D[bestfitplane7, {x, 0, maxx - minx}, {y, 0, maxy - miny}, PlotStyle → Opacity[0.75]];
```

In[17]:=
```
horizontalplaneplot = Plot3D[Mean[elevations], {x, 0, maxx - minx},
   {y, 0, maxy - miny}, PlotStyle → {Opacity[0.25], RGBColor[1, 1, 0]}];
```

Here is an oblique view of the measured points (red), best-fit plane(purple), and a horizontal plane for reference (yellow):

In[18]:=
```
Show[bestfitplot7, horizontalplaneplot, balls,
 BoxRatios → {maxx - minx, maxy - miny, maxz - minz}, AxesLabel → {"East", "North", "Elev"}]
```

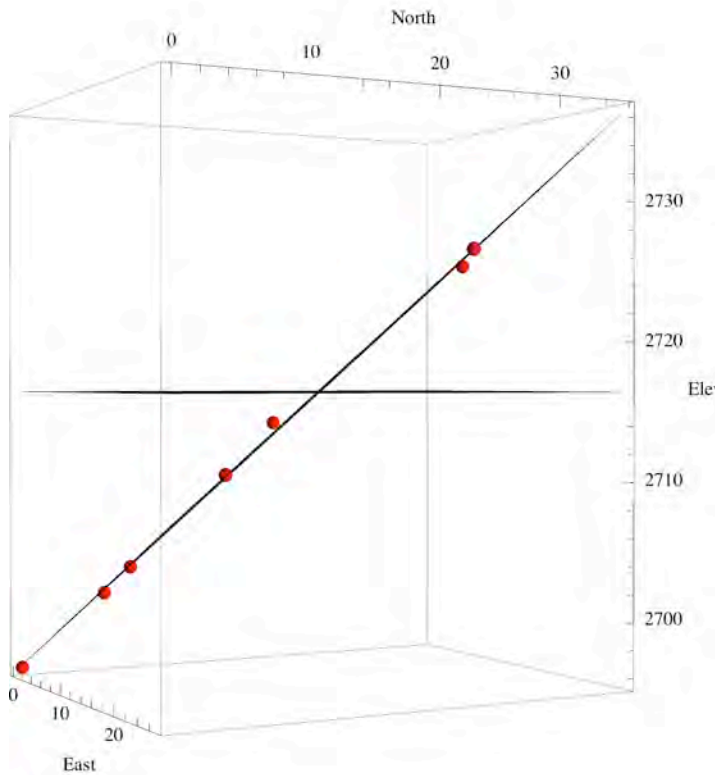
Out[18]=



Another view, this time looking along strike to show the deviations of the point measurements from the best-fit plane:

In[19]:=
```
Show[bestfitplot7, horizontalplaneplot, balls,
 BoxRatios → {maxx - minx, maxy - miny, maxz - minz}, AxesLabel → {"East", "North", "Elev"}]
```

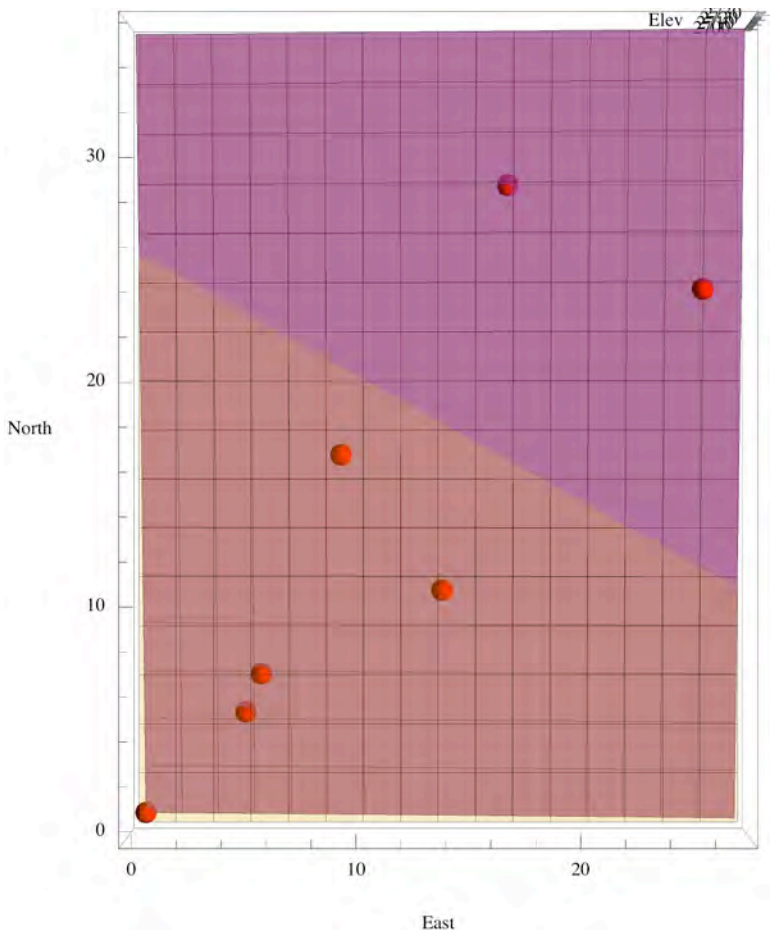
Out[19]=



The thin horizontal plane, which appears as a line in a down-strike view, is shown for reference. Here is another view of the same components looking straight down:

In[20]:=
```
Show[bestfitplot7, horizontalplaneplot,
 balls, BoxRatios → {maxx - minx, maxy - miny, maxz - minz},
 AxesLabel → {"East", "North", "Elev"}, ViewPoint → {0, 0, 20}]
```

Out[20]=



The intersection of the dipping best-fit plane and the horizontal plane indicate a strike of about 300°.

The dip angle and dip direction are calculated as shown in Haneberg (2004)

In[21]:= $\text{dipangle} = \text{ArcTan}\left[\sqrt{(\partial_x \text{ bestfitplane7})^2 + (\partial_y \text{ bestfitplane7})^2}\right] / \text{Degree}$

Out[21]= 42.1924

In[22]:= $\text{dipdirection} = \text{ArcTan}\left[-\partial_y \text{ bestfitplane7}, -\partial_x \text{ bestfitplane7}\right] / \text{Degree}$

Out[22]= -150.826

In this formulation, dip directions are measured positive-clockwise. Thus, a dip direction of -135° is equivalent to

In[23]:= 360 + %

Out[23]= 209.174

Calculation of elevations for specified eastings and northings (all data points)

First, construct a table containing the known *x* and *y* values along with their descriptions as supplied by Balin:

In[37]:=
```
Clear[x, y, data]
```

In[38]:=
```
data = {{"RKS-12", 737 251.21, 1 426 220.01},
{"RKS-18", 737 296.78, 1 426 299.70}
  };
```

Next, use the specified *x* and *y* values into the best-fit plane equation and show the results as a table.

In[39]:=
```
minx
miny
```

Out[39]= 1.42626×10^6

Out[40]= 737 314.

In[42]:=
```
TableForm[
 Table[{data[[i, 1]], data[[i, 3]], data[[i, 2]],
   bestfitplane7 /. {x → data[[i, 3]] - minx, y → data[[i, 2]] - miny}}, {i, Length[data]}
 ], TableHeadings → {None, {"Description", "Easting", "Northing", "Elevation"}}
]
```

Out[42]//TableForm=

Description	Easting	Northing	Elevation
RKS-12	1.42622×10^6	737 251.	2630.23
RKS-18	1.4263×10^6	737 297.	2701.52

References

Haneberg, W.C., 2004, *Computational Geosciences with Mathematica*: Berlin, Springer-Verlag.

Digital Outcrop Modeling and Structural Mapping, I-90 Snoqualmie Pass East, Hyak to Keechelus Dam, Washington (2008 Field Season)

Prepared by

William C. Haneberg, PhD, LEG

Prepared for

Wyllie & Norrish Rock Engineers
Fisher & Strickler Rock Engineers
URS Corporation

November 17, 2008

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Appendix D: Structural Data from 3-D Models— Planes ..... Data DVD

Appendix E: Structural Data from 3-D Models— Traces ..... Data DVD

Purpose

Digital 3-D models of selected rock exposures along the westbound lane of I-90 between Hyak and Keechelus Dam were created using close range terrestrial digital photogrammetry and used for structural mapping in support of rock slope design along the highway. The work described in this report was a continuation of that undertaken during the 2006 and 2007 field seasons, for which previous report were prepared.

This report contains a description of the 2008 fieldwork and data processing, screen-capture images of each 3-D model for which structural mapping was performed, and appendices containing the digital models and the orientations and locations of measured rock mass discontinuities.

Sirovision 3.2 software, developed and supported by the Commonwealth Scientific and Industrial Research Organization (CSIRO) Mining and Exploration Division, was used to create the 3-D outcrop models. The software consists of two applications: Siro3D for 3-D model creation and SiroJoint for structural mapping and analysis. Additional information about the software is available at www.sirovision.com. Virtual structural mapping of rock faces using 3-D photogrammetric models is an established method that has been successfully applied on projects involving highway cuts (including nearby portions of I-90), surface mines and quarries, and underground mines (e.g., Haneberg, 2008; Haneberg and Medley, 2007; Haneberg *et al*, 2007; Haneberg *et al*, 2006; Poropat, 2006; Tonon and Kottenstette, 2006).

Fieldwork

The stereo pairs of photographs used in the 2008 work were taken in September 2008 by Fisher & Strickler Rock Engineering and provided to Haneberg Geoscience for processing. Photographs taken the 2006 field season were assigned two-digit numbers (e.g., 42) and referred to as the 000 series. Photographs taken during the 2007 field season were assigned three-digit numbers (e.g., 101 or 202) and referred to as the 100 and 200 series. Photographs taken during the 2008 field season were assigned three-digit numbers (e.g., 801) and referred to as the 800 series.

The photographs were taken using Nikon D200 digital SLR cameras with Nikkor AF-D 20 mm f2.8, AF-D 24 mm f2.8, or AF-D 50 mm f1.8 lenses, all of which are supported by the Sirovision software used in this project, mounted on a standard camera tripod with a pan head. Beyond the use of a camera and lenses supported by the software, no special calibration was performed for this routine structural mapping. A plumb bob used to mark each camera station and a retractable steel tape used to measure camera height at each station. The files were saved as native Nikon NEF (also known as RAW) files to allow for greater processing flexibility and lossless conversion to the tiff format required by Sirovision.

Camera stations were marked on the shoulder or Jersey barrier of the eastbound lane of I-90. Control points were marked and numbered on the modeled rock faces using spray paint. The locations of both the camera stations and control points were later surveyed with RTK GPS and a total station by White Shield, Inc. and the coordinates provided in an Excel spreadsheet (Appendix A and data DVDs). This information was used to establish the scale, orientation, and geo-referenced coordinates of the 3-D models within the Washington State Plane coordinate system (NAD 83 and NAVD 88). The locations of the surveyed control points for the 2006, 2007, and 2008 photographs are superimposed on a USGS 1 m orthophoto in Figure 1.

Image Processing and 3-D Model Creation

The digital photographs were first converted from NEF format, which allows for maximum flexibility if any image adjustments are necessary, to the tiff format required by Sirovision. Several of the original digital photographs were substantially overexposed and the required substantial exposure adjustment, which was performed on 16 bit NEF files before exporting the results as 8 bit tiff files. The exposure adjustment may have had an effect on the amount of detail shown in the models, although all of the models proved to be usable for structural mapping. Each photograph was then corrected to remove lens distortion using the default Sirovision parameters for the appropriate lens, and each pair was combined with the survey information to set up the 3-D orientation for each pair. This processes uses the camera station, camera height, and control point locations for each model and requires that the surveyed control point and three other common (but not surveyed) points be identified in each photograph. A 3-D model area was then defined for each pair, using as much of the overlap area as was practical in each case. Irregular topography, trees, and brush along the tops of the road cuts complicated this task and, as a consequence, some of the models are either truncated along their top edge or contain irregularities near the trees and brush. Finally, 3-D models were generated using batch processing within Sirovision. Each 3 by 3 block of pixels in the defined overlap area yielded one spatial data point on the outcrop face, which yielded models typically consisting of approximately several hundreds of thousands xyz points each. The models were saved as Sirovision rectified tiff files containing 3-D information. Other formats, including ascii xyz or dxf files of the underlying 3-D meshes, were not exported but are available upon request.

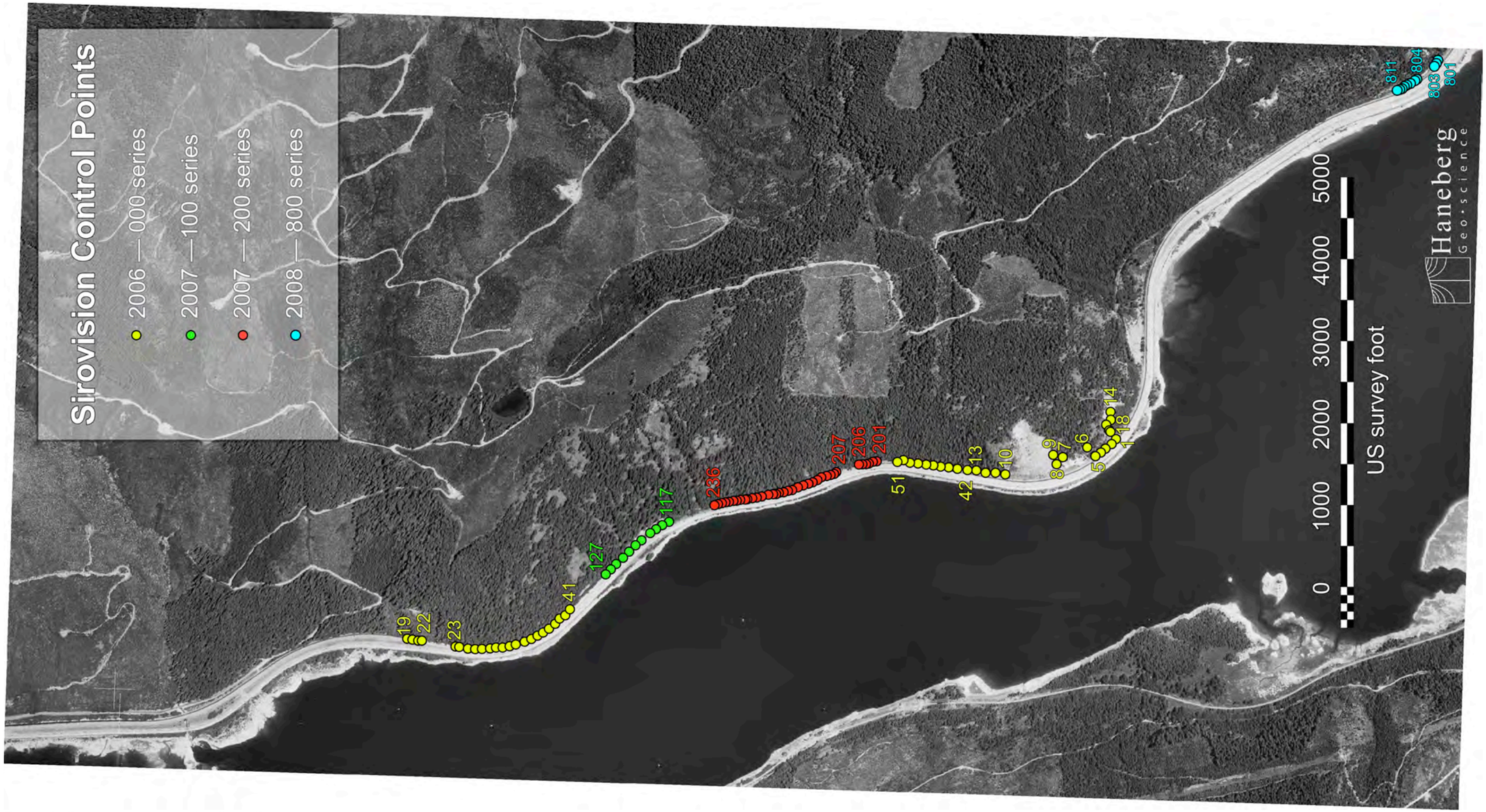


Figure 1. Control point layout for Slide Curve outcrop models

Structural Mapping

Virtual structural mapping of selected rock mass discontinuities and lithologic contacts was performed during October and November 2008. Preliminary results were reviewed by Fisher & Strickler Rock Engineers, and revised with the addition of additional discontinuities as requested. Figure 2 shows a typical SiroJoint model with a number of joint surfaces mapped as closed polygons and traces intersecting the rock surface.

Each SiroJoint model includes discontinuities identified during virtual mapping sessions, the orientations of which were exported and delivered electronically to Wyllie & Norrish Rock Engineers and Strickler's Geological Consulting for further plotting, analysis, and incorporation into slope designs. In addition to dip angles and dip directions, SiroJoint calculates the coordinates of the center, area, maximum chord length, the coordinates of the top and bottom edges for joints mapped as polygons. The coordinates of each point defining 3-D traces to which planes were fitted were also exported. Fisher & Strickler Rock Engineers compared Sirovision discontinuity orientations were compared to manual measurements obtained with a geological compass, and the results are discussed separately in their report.

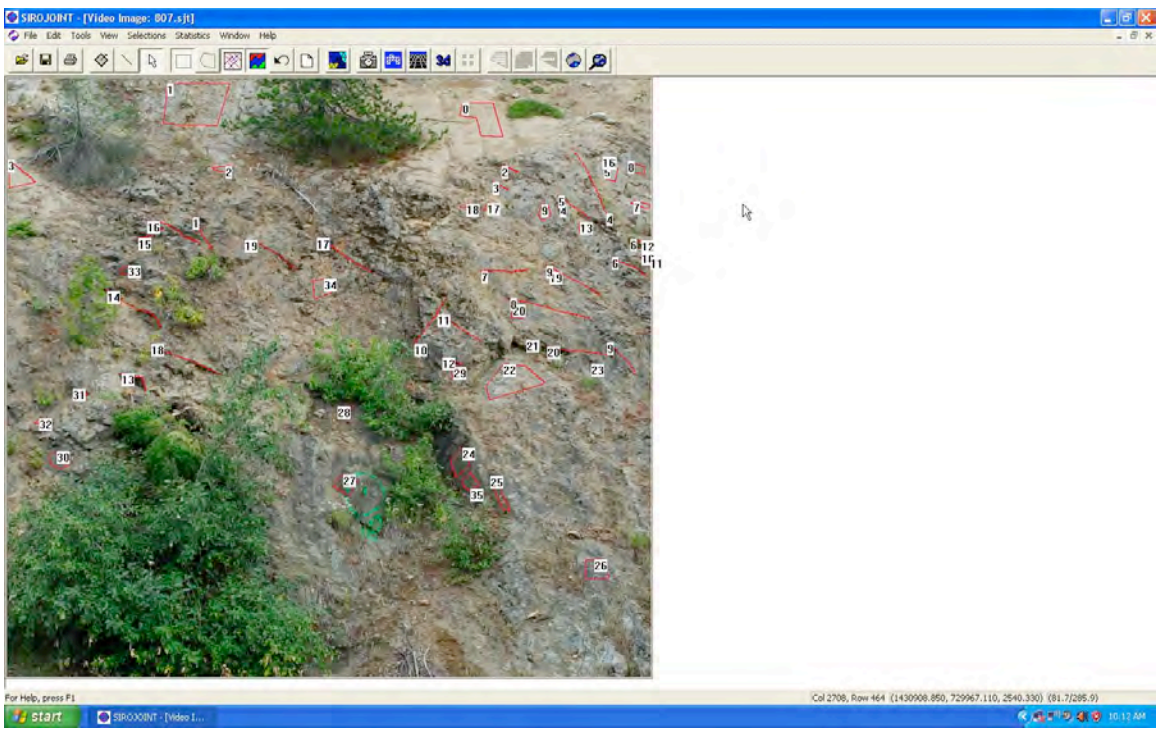


Figure 2. SiroJoint 3-D model 807 from the I-90 Hyak to Keechelus Dam project, showing mapped joint planes as numbered red polygons and traces as numbered red lines. Dips and dip directions were calculated by Sirovision, using best-fit planes to the polygons and traces. The polygon and line ID numbers in the image correspond to those listed in Appendices D and E and on the data DVDs.

Screen captures of the SiroJoint models are included in Appendix C of this report. SiroJoint 3-D models showing the mapped discontinuities and comma-delimited (CSV) text files containing the exported structural data are included on the report DVD (Appendices D, E, and F). Because of their sizes, Appendices D, E, and F are provided only as electronic data files. The SiroJoint models (.sjt files) can be viewed using the Open command in the free Sirovision viewer (available from www.sirovision .com). The discontinuity data files (.csv) can be opened using a text editor such as WordPad (not Notepad) or spreadsheet programs such as Excel (it may be necessary to choose All Files for file type).

REFERENCES CITED

Haneberg, W.C., 2008, Experience using close range terrestrial digital photogrammetry for 3-D rock slope modeling and discontinuity mapping in the United States: *Bulletin of Engineering Geology and the Environment*, v. 67, no. 4, p.457-469.

Haneberg, W.C., Burk, R.L., Findley, D.P., and Norrish, N.I., 2007, Virtual structural mapping using 3-D digital rock slope models, I-90 near Snoqualmie Pass, Washington: *Geological Society of America 2007 Cordilleran Section Meeting Abstracts with Programs*, v. 39, no. 4, p. 24.

Haneberg, W.C., Norrish, N.I., and Findley, D.P., 2006, Digital outcrop characterization for 3-D structural mapping and rock slope design along Interstate 90 near Snoqualmie Pass, Washington: *Proceedings, 57th Annual Highway Geology Symposium*, Breckenridge, Colorado, September 27-29, 2006, p. 146-160.

Poropat, G.V., 2006, Remote 3D mapping of rock mass structure, *in* F. Tonon and J.T. Kottenstette (eds), *Laser and Photogrammetric Methods for Rock Face characterization*: American Rock Mechanics Association, Alexandria, Virginia, pp. 63-75.

Tonon, F. and Kottenstette, J.T., 2006, Summary paper on the Morrison field exercise, *in* F. Tonon and J.T. Kottenstette (eds), *Laser and Photogrammetric Methods for Rock Face characterization*: American Rock Mechanics Association, Alexandria, Virginia, pp pp. 78-93.

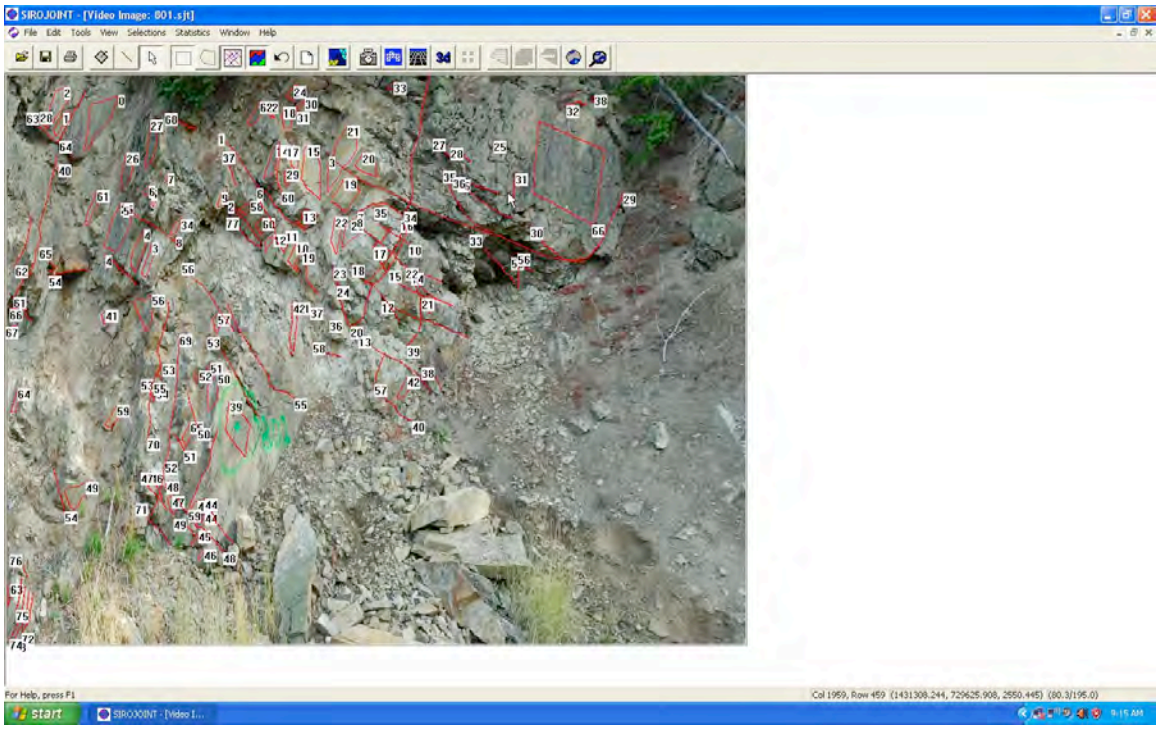
Appendix A: Surveyed Camera and Control Point Locations

I-90 Snoqualmie Pass East - Hyak to Keechelus Dam WSDOT Contract: Y-9764 WSDOT Project Number XL-2779					
2008 Borehole-Geotech Features					
(Combine Factor = 0.99988231 West Control) WSDOT PD = SPC / CF + 328083.333					
Units:	U.S. Feet				
Vertical:	NAVD 1988				
Zone:	Washington Coordinate System, South Zone, NAD 1983/91			cf=	0.999882310
Local Datum Project				State Plane	
N-LDP	E-LDP	Ground Elevation	Description	Northing	Easting
1060942.94	1757594.75	2535.56	IS112	732773.36	1429343.18
1057797.74	1759546.72	2545.38	PMS 801	729628.53	1431294.92
1057728.02	1759481.51	2536.27	PMS 801L	729558.81	1431229.71
1057718.93	1759491.42	2536.41	PMS 801R	729549.73	1431239.63
1057816.50	1759507.69	2543.07	PMS 802	729647.29	1431255.89
1057756.65	1759450.45	2536.22	PMS 802L	729587.44	1431198.66
1057748.04	1759458.77	2536.24	PMS 802R	729578.83	1431206.98
1057841.08	1759472.43	2544.25	PMS 803	729671.86	1431220.64
1057788.53	1759417.11	2536.16	PMS 803L	729619.32	1431165.32
1057780.31	1759424.46	2536.09	PMS 803R	729611.10	1431172.67
1058053.85	1759314.85	2536.29	PMS 804	729884.60	1431063.08
1058013.53	1759237.00	2535.19	PMS 804L	729844.29	1430985.24
1058002.23	1759243.69	2535.33	PMS 804R	729832.99	1430991.92
1058079.00	1759297.72	2534.59	PMS 805	729909.75	1431045.95
1058040.95	1759218.36	2535.08	PMS 805L	729871.71	1430966.59
1058030.29	1759225.23	2535.14	PMS 805R	729861.05	1430973.47
1058132.03	1759263.36	2535.22	PMS 806	729962.78	1431011.59
1058098.00	1759182.59	2534.92	PMS 806L	729928.75	1430930.83
1058088.16	1759188.40	2534.91	PMS 806R	729918.91	1430936.64
1058177.45	1759243.79	2543.46	PMS 807	730008.19	1430992.03
1058136.37	1759160.61	2534.77	PMS 807L	729967.11	1430908.85
1058125.13	1759167.06	2534.83	PMS 807R	729955.88	1430915.31
1058207.18	1759225.87	2541.76	PMS 808	730037.92	1430974.10
1058170.85	1759141.30	2534.43	PMS 808L	730001.59	1430889.54
1058158.81	1759147.26	2534.37	PMS 808R	729989.55	1430895.51
1058234.33	1759199.72	2536.83	PMS 809	730065.07	1430947.96
1058212.04	1759121.59	2534.16	PMS 809L	730042.78	1430869.84
1058201.19	1759126.90	2534.26	PMS 809R	730031.93	1430875.14
1058262.74	1759189.27	2536.42	PMS 810	730093.47	1430937.51
1058239.20	1759109.26	2534.02	PMS 810L	730069.94	1430857.51
1058228.91	1759113.97	2534.13	PMS 810R	730059.64	1430862.22
1058294.36	1759179.57	2543.73	PMS 811	730125.09	1430927.81
1058271.77	1759094.96	2533.92	PMS 811L	730102.50	1430843.21
1058260.11	1759100.03	2533.97	PMS 811R	730090.84	1430848.28

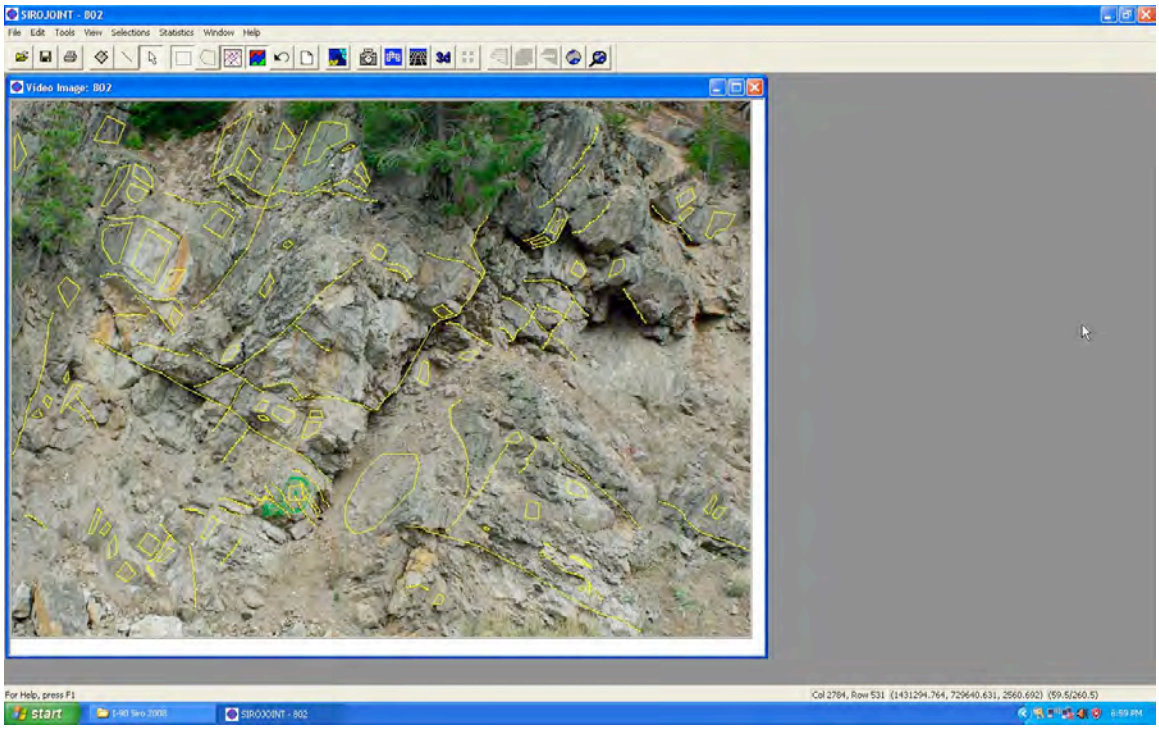
Appendix B: SiroJoint Screenshots

The images in Appendix B are two-dimensional projections of the 3-D outcrop models. Model numbers below each screenshot refer to the control points shown in Figure 1 and listed in Appendix A.

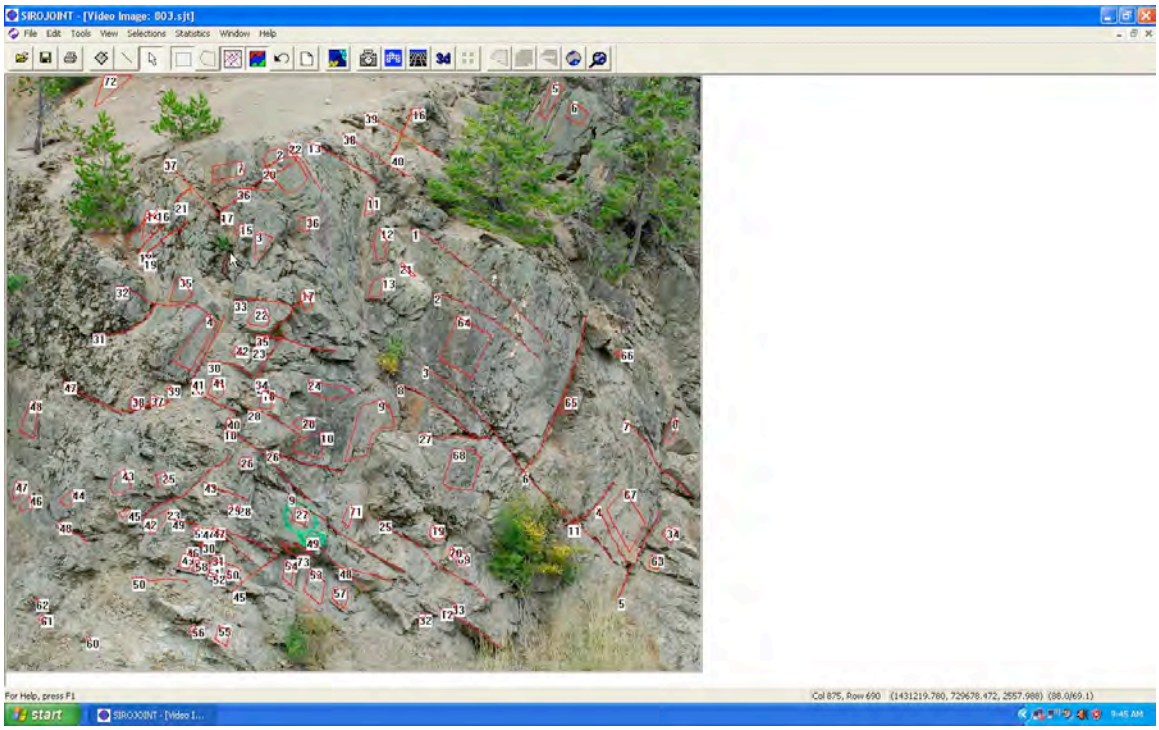
Digital SiroJoint 3-D models that can be opened and manipulated using SiroJoint software or the free Sirovision viewer (www.sirovision.com) are included on the data DVD as Appendix C. Joint ID numbers shown in the screenshots are keyed to orientations listed in Appendices D (polygons/planes) and E (traces/lines) on the data DVD.



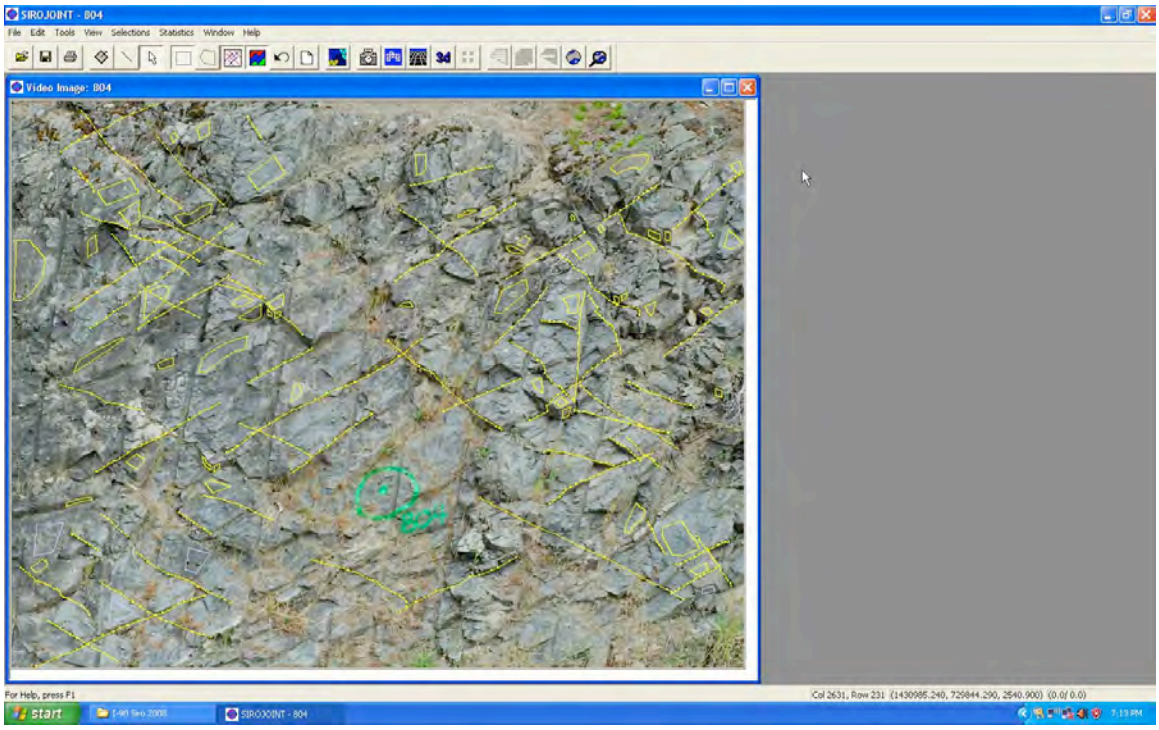
Outcrop Model 801



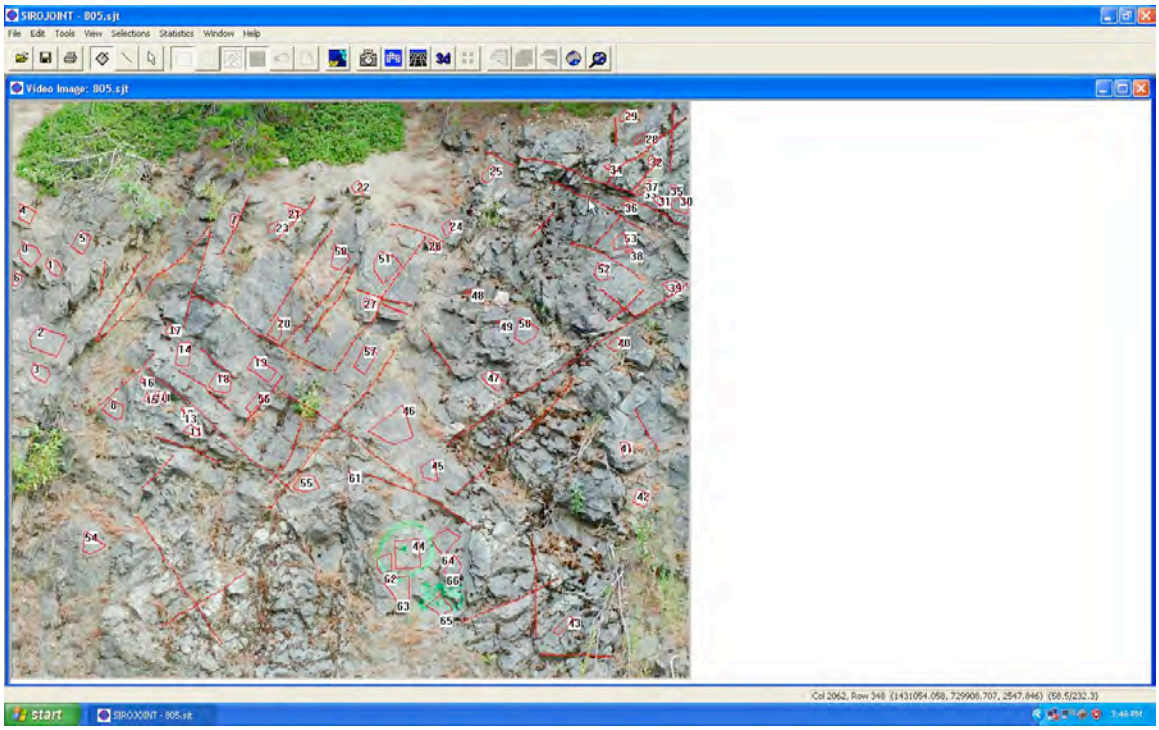
Outcrop Model 802



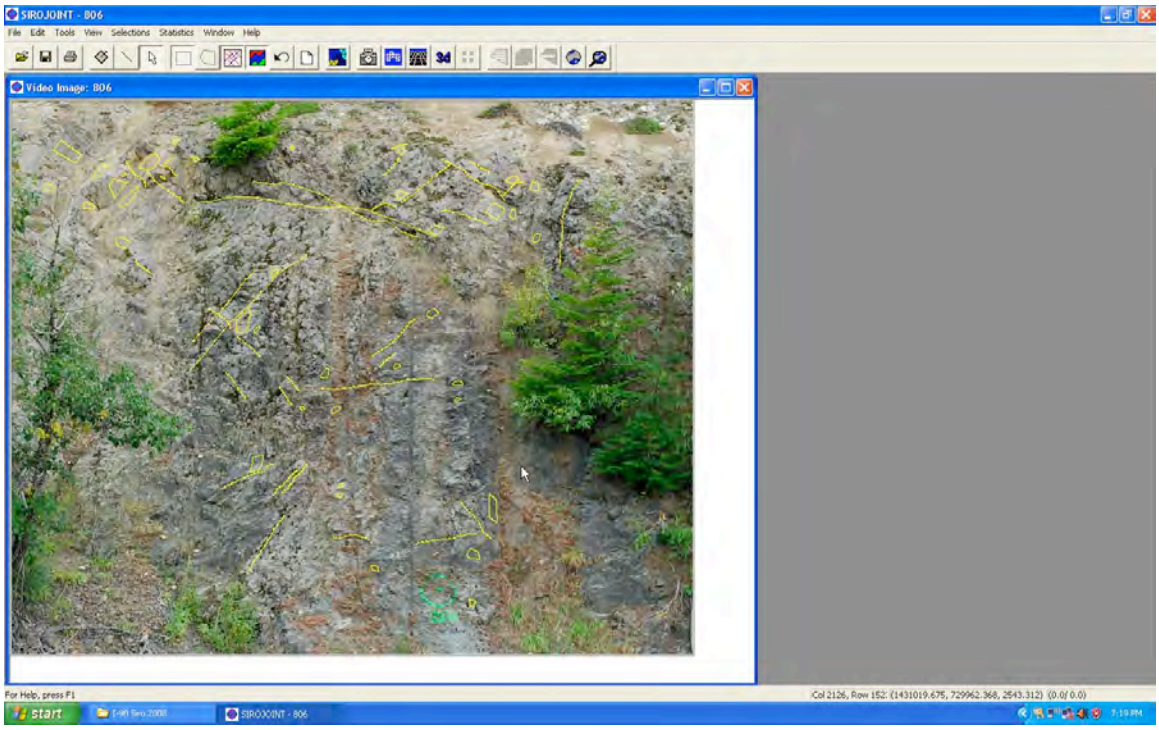
Outcrop Model 803



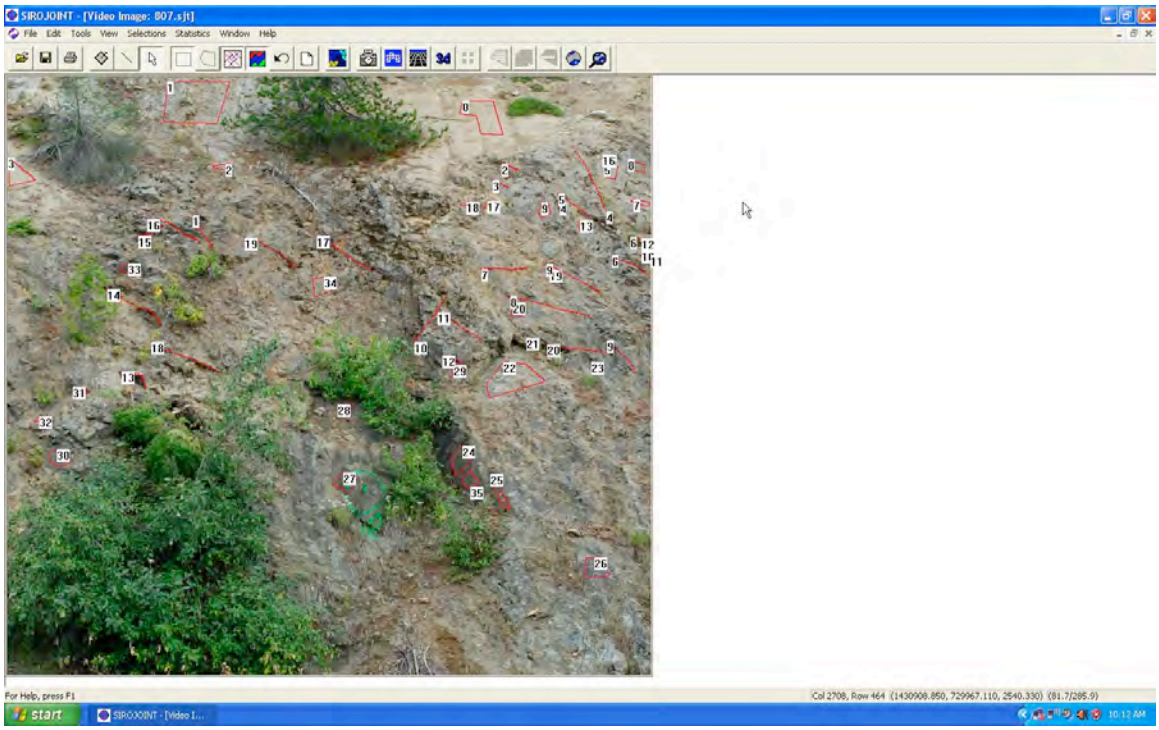
Outcrop Model 804



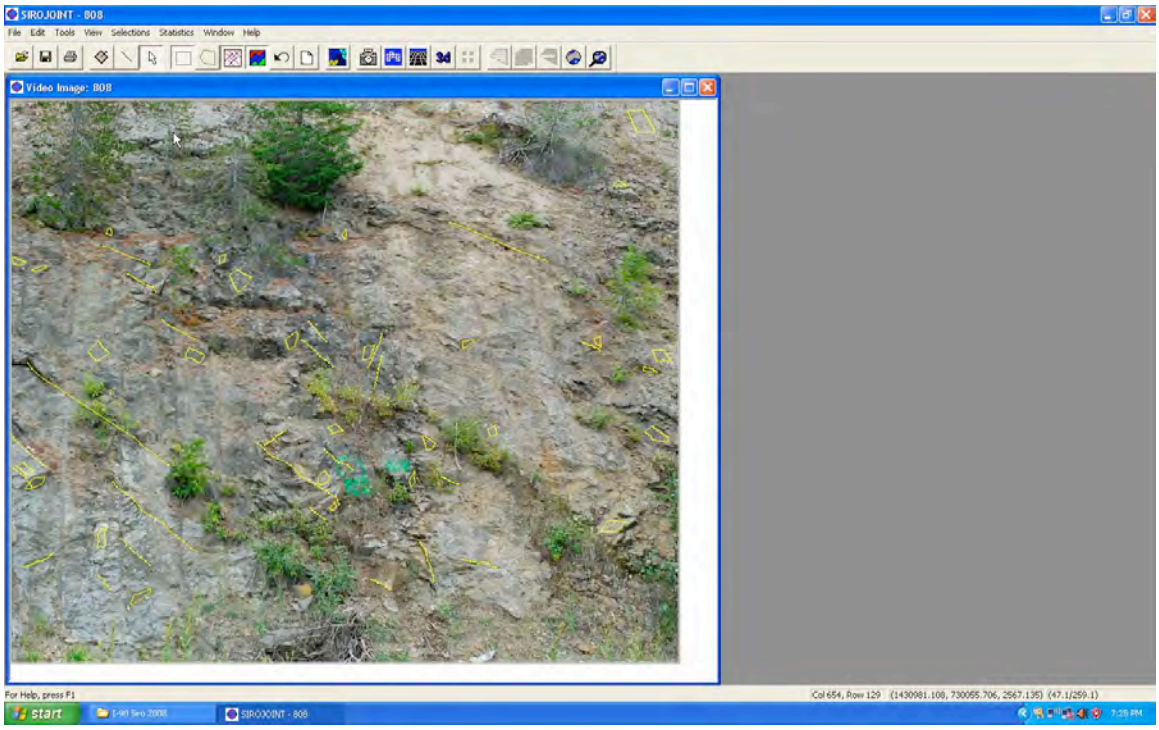
Outcrop Model 805



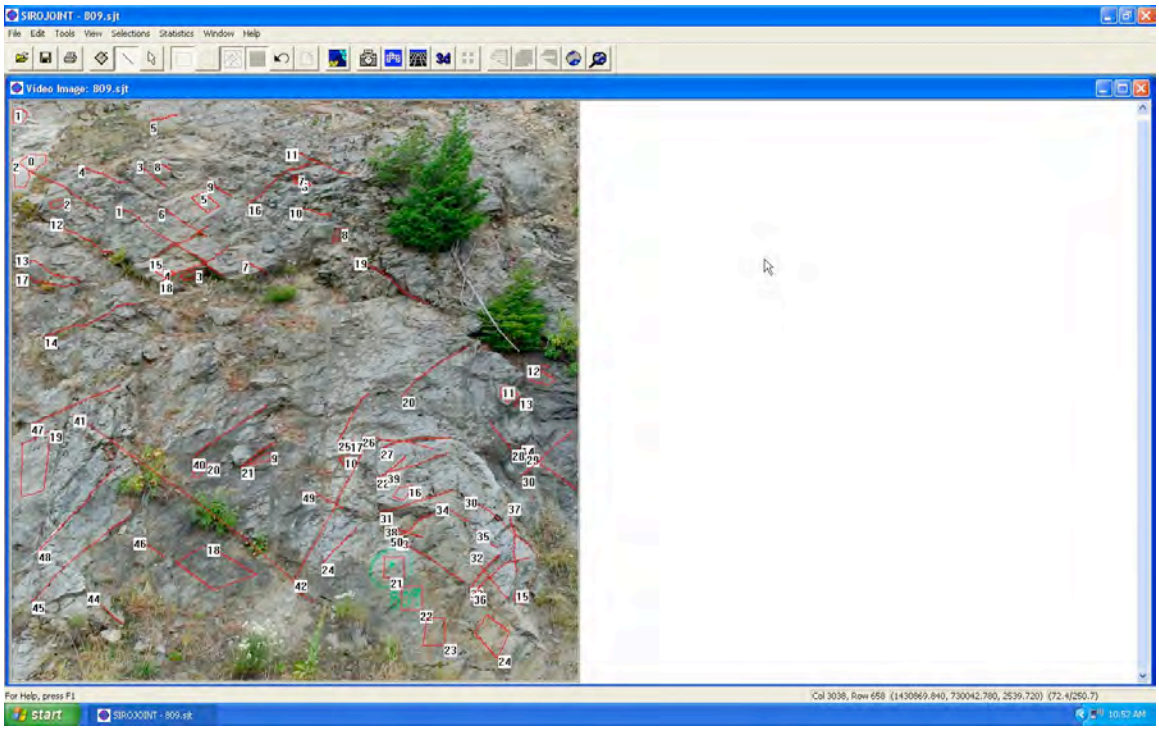
Outcrop Model 806



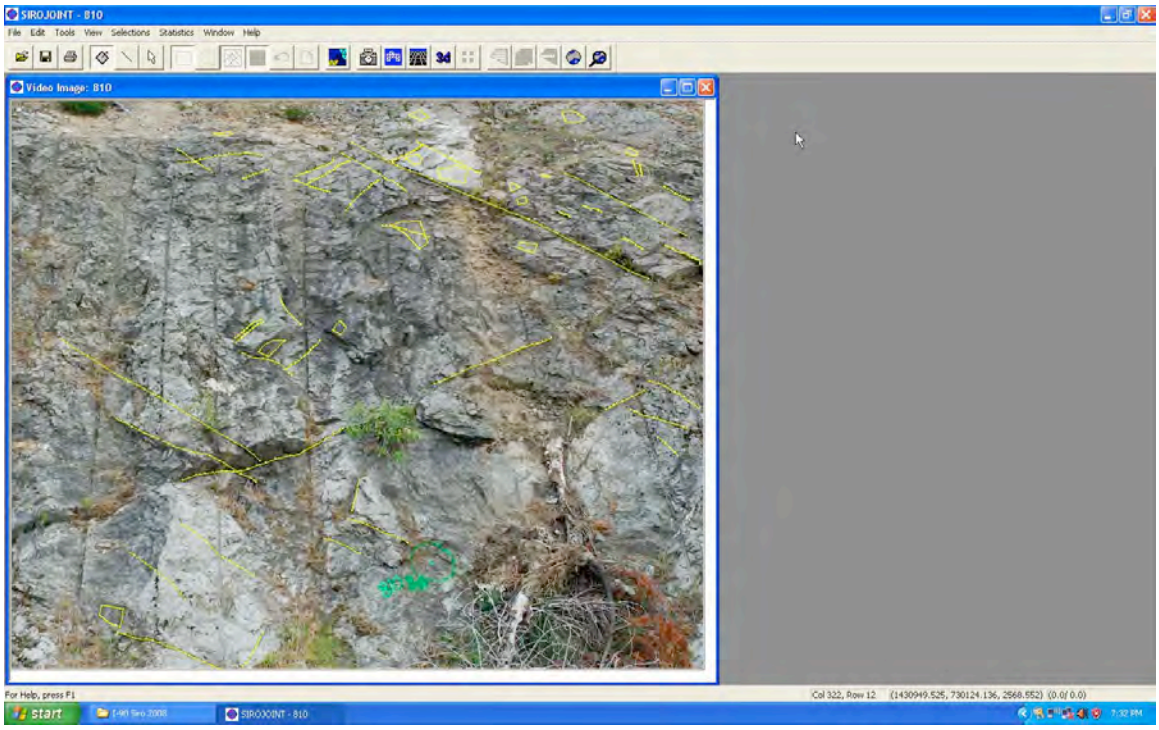
Outcrop Model 807



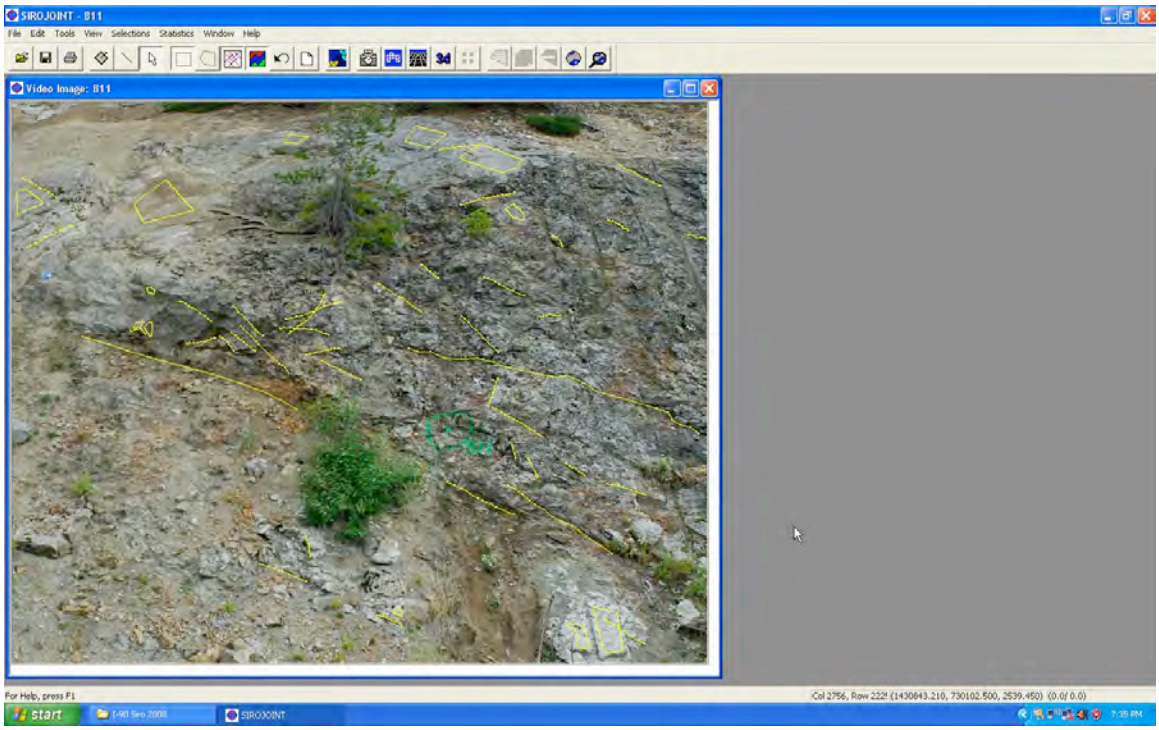
Outcrop Model 808



Outcrop Model 809



Outcrop Model 810



Outcrop Model 811