SOFTWARE VALIDATION TEST RESULTS FOR STEREOSTAT®, VERSION 1.2

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1 SCOPE OF THE VALIDATION

This document presents the Software Validation Test results for validation of the installation and functionality of *StereoStat®* (version 1.2). *StereoStat®* was acquired by the Center for Nuclear Waste Regulatory Analyses (CNWRA) to support technical assistance activities to the U.S. Nuclear Regulatory Commission (NRC) in its high-level waste program. *StereoStat®* replaces the previously validated and QA-approved program, *Stereonet for Windows*, which was found to be incompatible with the Microsoft® Windows XP operating system. Also, RockWare (which now markets *Stereonet for Windows*) has indicated that it no longer plans to update or support *Stereonet for Windows*.

These test results are intended to validate *StereoStat®* program features that are used for visualizing, analyzing, and interpreting geological data that describe planar and/or linear features (e.g., bedding, fractures, foliation, slickenlines, etc.). Features of the software that are validated include: (1) ability to plot planar (either as great circle traces or as poles to planes) and linear data (poles); (2) construction of rose diagrams; (3) contouring; and (4) statistical analysis. This test is based on the software validation test plan for *StereoStat®, version 1.2* (Smart, 2003).

2 ENVIRONMENT

2.1 Software and Operating System Requirements

StereoStat® (version 1.2) is developed and marketed by RockWare, Inc., Golden, Colorado. Version 1.2 runs on the Microsoft® Windows 98/ME/NT/2000/XP operating systems. Other than the operating system, no other software is required for installation and use of *StereoStat®*. Data can be imported from an ASCII text file created with a text editor or standard spreadsheet, such as Microsoft® *Excel* (file format can be tab-delimited, comma-delimited, or space-delimited), or can be directly entered by the user.

2.2 Hardware Requirements

StereoStat® (version 1.2) requires a 200 MHz Pentium (or faster) processor, and a minimum of 16 Mb of RAM and 10 Mb of hard disk space. The validation tests were performed on a 2.8 GHz Pentium 4 workstation with 512 MB of RAM and a 42 GB hard drive. *StereoStat®* can export data and analyses in a variety of formats (Adobe® *Illustrator®* AI, BMP, WMF, and *AutoCAD®* DXF) and can print to any Windows-installed printer (including Adobe® *Acrobat®* for production of PDF files).

2.3 Test Machine Specifications

The validation tests were performed on a 2.8 GHz Pentium 4 workstation. This machine is equipped with 512 MB of RAM, a 42 GB hard drive, and the Microsoft® Windows XP operating system (version 2002).

3 PREREQUISITES

Prerequisites for successful installation and application of *StereoStat*® (version 1.2) include an appropriate level of hardware and operating capabilities, as described in Section 2. Installation of software and license files requires administrator privileges. These privileges are not necessary to run the software once installation is complete.

4 ASSUMPTIONS AND CONSTRAINTS

Any user of *StereoStat*® is assumed to have a basic familiarity with planar and linear geologic data, and the basic types of plots (e.g., great circles, poles to planes, rose diagrams) and analysis tools (e.g., 1% contouring) that are available. The standard program installation provides an HTML-format help page that also contains a short tutorial that can be accessed from the main help menu.

5 TEST CASES

This validation test follows CNWRA requirements as outlined in Section 5.10 of TOP-018 (CNWRA, 2003) and the test cases are described in the software validation test plan (Smart, 2003). Two shareware stereonet programs are used for the comparative testing – *StereoWin* version 1.1.6 (Allmendinger, 2003) and *GEOrient*, version 9.2 (Holcomb, 2003). Both programs have been used by the author for prior research and teaching applications, and each will be used in demo/evaluation mode. The tests will be considered successful if results from the various programs and earlier test cases are the same as the results from *StereoStat*®.

5.1 Test Case 1 – Verifying Accuracy of Plotted Planes and Lines

The ability to plot planar (either as great circle traces or as poles to planes) and linear data (poles) is a fundamental aspect of stereographic analysis.

5.1.1 Test Input

The test input for this case consists of five planes listed in Table 1.

5.1.2 Test Procedure

The test planes were entered as a "New Dataset" in *StereoStat*®. The "Plot on Stereo Plot" option was used to plot the planes on an equal-area, lower-hemisphere stereo plot as planes (i.e., great circle traces). The planes were then plotted on an equal-area, lower-hemisphere stereo plot as poles (i.e., lines that are normal to the planes).

5.1.3 Test Results

The stereo plots for the planes (Fig. 1A) and poles to the planes (Fig. 1D) are visually identical to those output from *StereoWin* (Figs. 1B, 1E) and *GEOrient* (Fig. 1C, 1F). Based on the result, test case 1 is considered successful.

5.2 Test Case 2 – Verification of Rose Diagram Functionality

Rose diagrams are the circular equivalent of traditional histograms where the number or percentage of strike values within a certain sampling window (typically 10°) are plotted graphically on a stereonet. Rose diagrams allow rapid determination of multiple modes within data set (e.g., orientation of systematic fracture sets from a suite of fracture measurements).

5.2.1 Test Input

The test input for this case are 14 planes listed in Table 2.

5.2.2 Test Procedure

The test planes were entered as a "New Dataset" in *StereoStat*® and the "Plot on Rose Plot" option was used to generate a standard bi-directional rose diagram with a 10° class bin.

5.2.3 Test Results

The output from *StereoStat*® (Fig. 2A) is found to be visually identical to the output generated by *StereoWin* (Fig. 2B) and *GEOrient* (Fig. 2C). Based on this result, test case 2 is considered successful.

5.3 Test Case 3 – Verification of Contouring Functionality

Contouring of polar data is a standard technique for analyzing large amounts of orientation information (e.g., using poles bedding planes to deduce fold axis orientation). The most common contouring methods are the 1% area and Kamb methods (Kamb, 1959; Turner and Weiss, 1963). The primary difference between methods is the size of the counting circle. For the 1% area technique, the area of the counting circle is 1% of the area of the stereonet, regardless of number of data points. In contrast, the Kamb method employs a variable counting circle size that varies as a function of the number of data points.

5.3.1 Test Input

The test input for this case consists of a portion of a previously published and analyzed set of metamorphic foliation data (Smart *et al.*, 1996). The data (n = 50) for test case 3 are listed in Table 3.

5.3.2 Test Procedure

The test data were written to an input text file named *StereoStat_SVTP_test-case-3.txt* that consists of two columns of data in ASCII text format. Column 1 is the strike of each foliation and column 2 is the dip of each foliation (right-hand rule convention). The input file was opened into *StereoStat*®. The "Contour Plot" option was used to generate both 1% area and Kamb contours of the poles to the foliations.

5.3.3 Test Results

The 1% area contour plot generated by *StereoStat*® (Fig. 3A) is compared the 1% contour plots from *StereoWin* (Fig. 3B) and *GEOrient* (Fig. 3C). Since *GEOrient* does not offer the option of Kamb contouring, the Kamb contour plot generated by *StereoStat*® (Fig. 3D) is compared to the output from *StereoWin* (Fig. 3E). The three 1% area contour plots are visually the same and the two Kamb contour plots are visually the same, so test case 3 is considered successful. Note that the contour plots generated by the three different programs are not absolutely identical. This reflects differences in the way that the graphical output is generated and is not due to any calculation error.

5.4 Test Case 4 – Verification of Statistical Algorithms

Along with contouring, statistical analysis of spherical data sets is a standard technique in structural geology. It is often necessary to determine the mean value of a population of linear data (e.g., poles of fractures). Several statistical options are normally available, including a circular distribution (Ramsay, 1967; Fisher *et al.*, 1987) or Bingham axial distribution (Mardia and Jupp, 2000), and a principal component analysis (Watson, 1966).

5.4.1 Test Input

Test case 4 makes use of the same data set that is used for test case 3.

5.4.2 Test Procedure

The input file was re-opened into *StereoStat*®. The "Analyze Data" option was used to conduct a Fisher analysis (i.e., calculation of a vector mean and/or confidence interval) and a principal component analysis of the poles to the foliation planes.

5.4.3 Test Results

Output from *StereoStat*® are compared to output generated by *StereoWin* and *GEOrient* (Table 4). For the Fisher analysis, comparison is in terms of the trend/plunge of the mean pole to foliation and the size of the 95% confidence cones (in degrees). The mean pole to foliation is identical for all programs. The 95% confidence cones are within 1° of each other. Both *StereoStat*® and *StereoWin* also report a concentration factor (or k-value) and these are found to be identical. For the *StereoStat*® principal component analysis, comparison is between the eigenvalues and eigenvectors determined by the Bingham analyses from *StereoWin* and *GEOrient*. All programs yield identical eigenvalues and eigenvectors, although the *StereoStat*® eigenvalues are multiplied by a factor of 50.

6 SUMMARY

All test cases were completed successfully. Therefore, it is recommended that *StereoStat*® version 1.2 be considered officially validated.

7 REFERENCES

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Table 1: Planes for use in test case 1.

Strike	Dip
152°	20°
332°	40°
154°	60°
334°	80°
156°	90°

Table 2: Planes for use in test case 2.

Strike	Dip
230°	20°
055°	40°
235°	40°
052°	60°
232°	60°
058°	80°
238°	80°
055°	50°
235°	50°
152°	20°
332°	40°
154°	60°
334°	80°
156°	90°

Table 3: Foliation data for use in test case 3.

Strike	Dip	Strike	Dip	Strike	Dip	Strike	Dip	Strike	Dip
120°	77°	130°	75°	155°	65°	138°	78°	145°	66°
122°	88°	133°	80°	158°	62°	138°	85°	146°	64°
122°	63°	133°	85°	160°	80°	138°	63°	148°	62°
124°	83°	135°	70°	160°	75°	140°	48°	150°	74°
124°	62°	135°	77°	161°	56°	140°	73°	150°	54°
125°	58°	135°	75°	161°	58°	140°	71°	150°	80°
125°	55°	135°	87°	162°	71°	140°	56°	152°	72°
126°	73°	135°	80°	165°	67°	141°	51°	153°	70°
130°	72°	137°	77°	165°	75°	143°	80°	154°	74°
130°	64°	137°	79°	165°	52°	145°	65°	154°	60°

Table 4: Analysis results for test case 4.

		StereoStat®	***StereoWin***	***GEOrient***
Fisher Analysis:				
Mean Pole to Foliation		052°/21°	052°/21°	052°/21°
95% Confidence Cone		3.97°	4.0°	4.02°
Concentration Factor (k)		26.638	26.6	*n.a.*
Bingham Analysis:				
Eigenvalues	Maximum	0.93	0.9285	0.928
	Intermediate	0.05	0.0462	0.046
	Minimum	0.03	0.0254	0.025
Eigenvectors	Maximum	052°/21°	052°/21°	052°/21°
	Intermediate	153°/27°	153°/27°	153°/27°
	Minimum	289°/55°	289°/55°	289°/55°

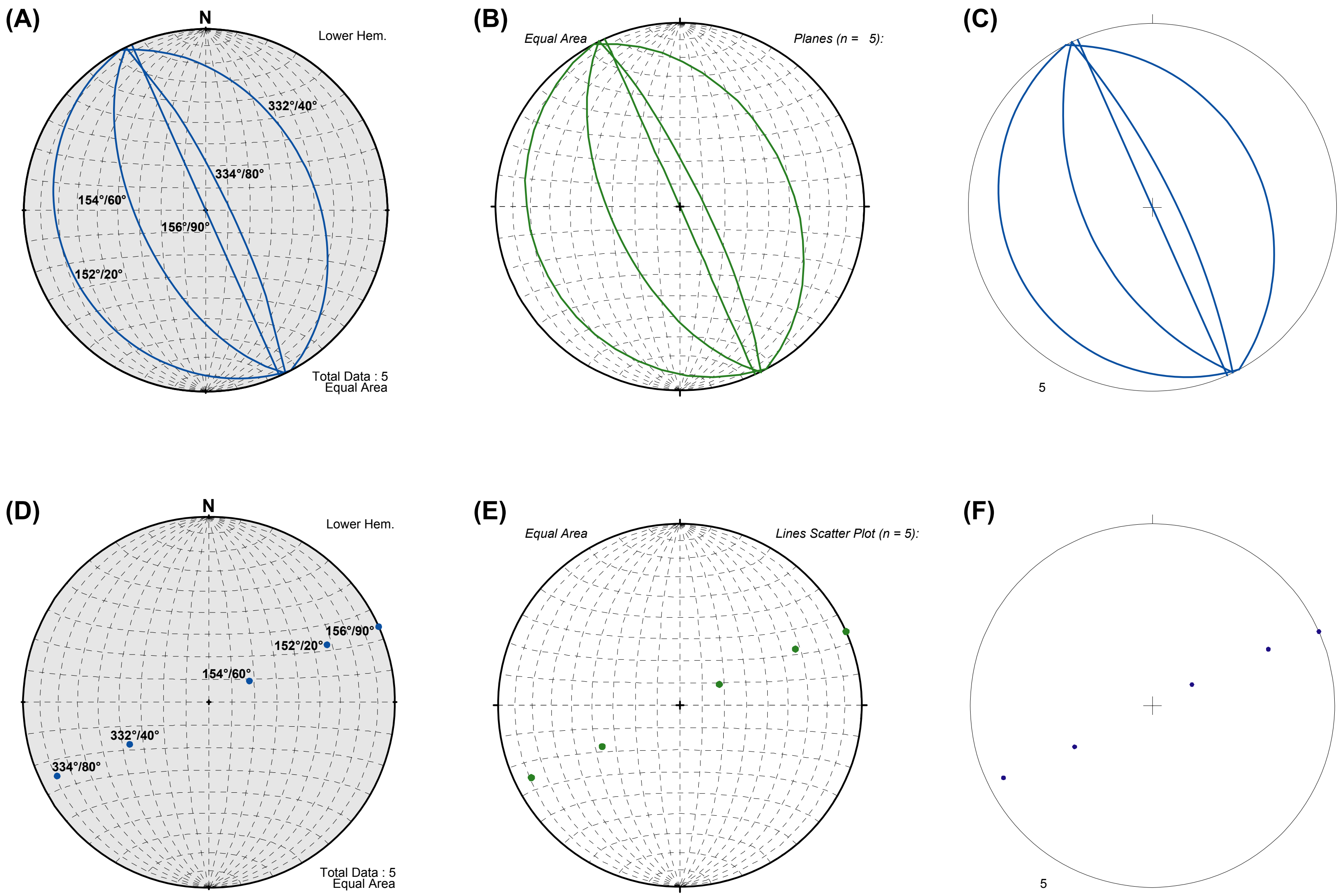

Figure 1. Equal-area stereonet plots for test case 1. Great circle plot of planes generated from (A) *StereoStat*®, (B) *StereoWin*, and (C) *GEOrient*. Scatter plot of poles to planes from (D) *StereoStat*®, (E) *StereoWin*, and (F) *GEOrient*.

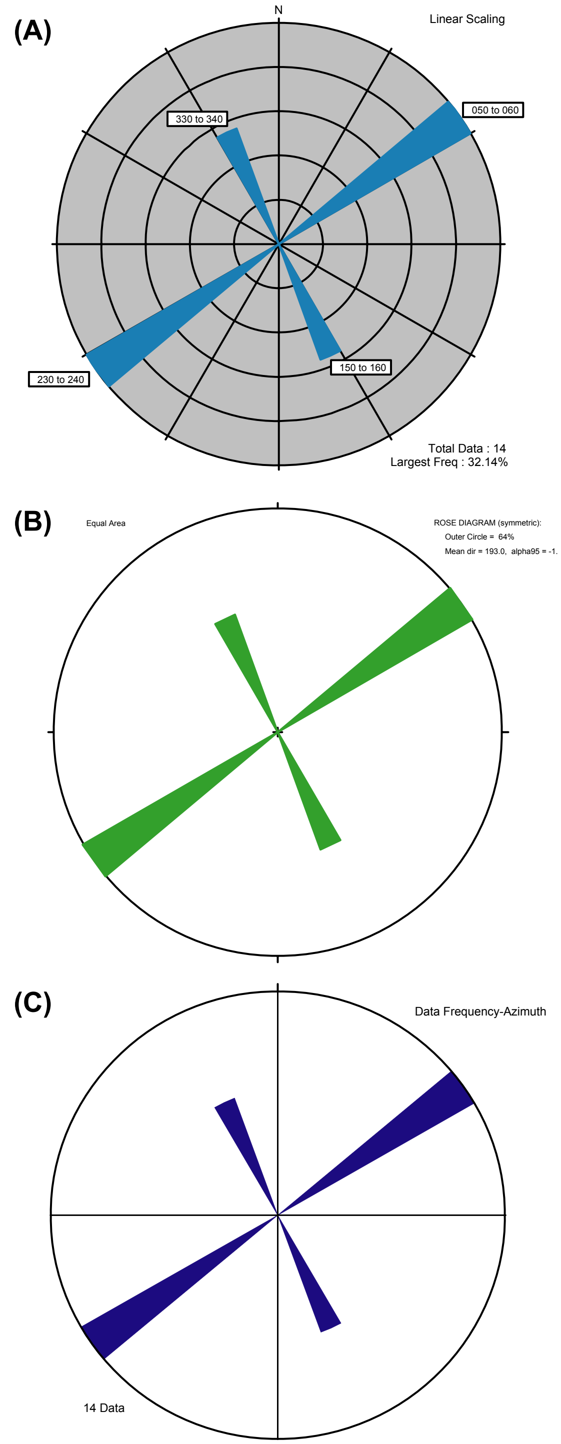

Figure 2. Rose diagram plots for test case 2 generated from (A) *StereoStat*®, (B) *StereoWin*, and (C) *GEOrient*.

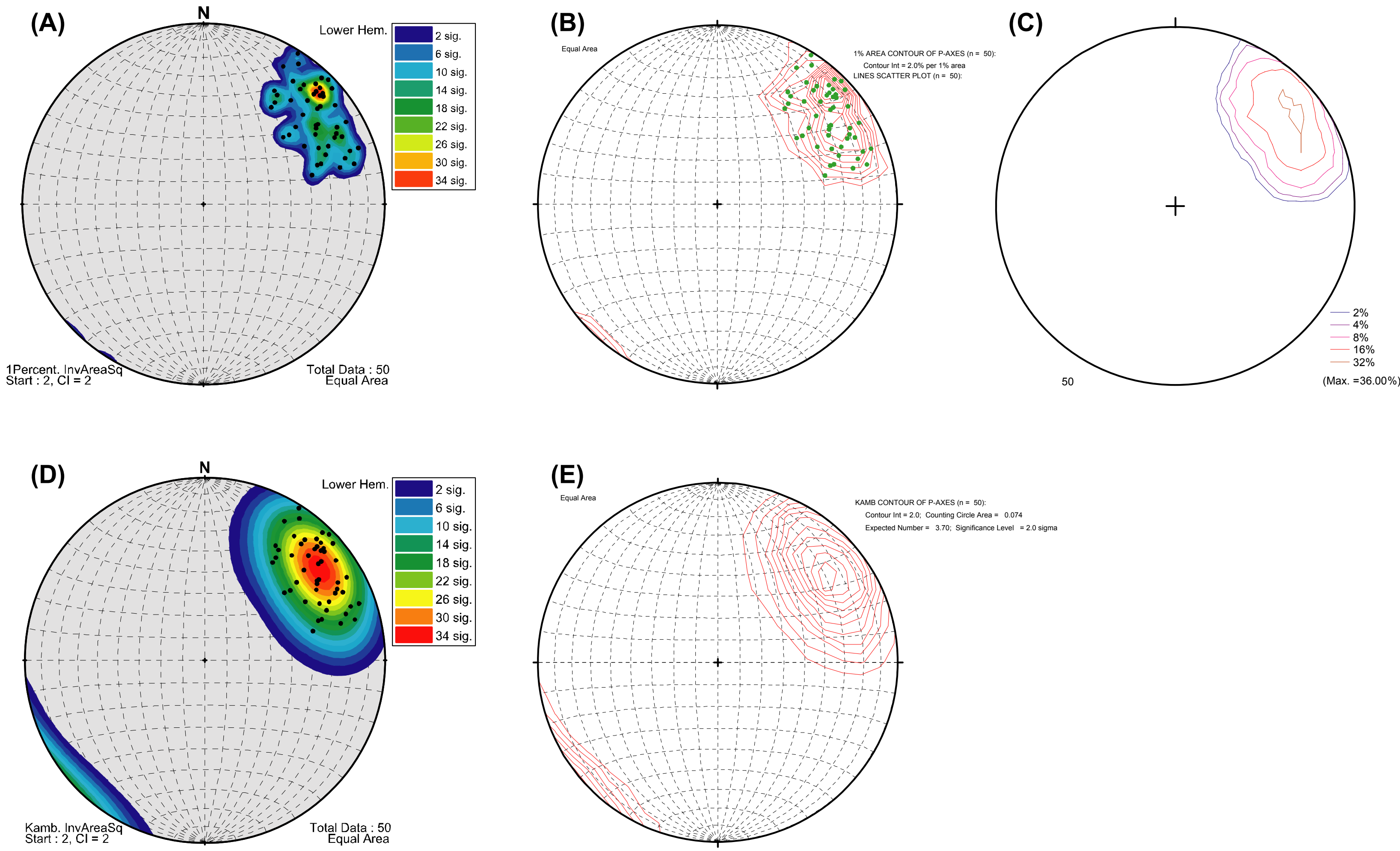

Figure 3. Contour plots for test case 3. 1% area contour plots generated from (A) *StereoStat*®, (B) *StereoWin*, and (C) *GEOrient*. Kamb contour plots generated from (D) *StereoStat*® and (E) *StereoWin*.