# GeoInsights 3D Software Test Document

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### Document Information

- **Document Title**: GeoInsights 3D Comprehensive Test Report
- **Version**: 1.0
- **Date**: August 2025
- **Prepared by**: GC
- **Software Version**: GeoInsights 3D v1.01
- **Test Environment**: Web Application (https://geoinsights3d.koyeb.app/)

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## Executive Summary

This document presents the results of comprehensive testing conducted on GeoInsights 3D, a geological drilling data analysis platform. Testing covered all major functionality including data loading, visualisation, statistical analysis, clustering, AI features, and export capabilities.

### Test Results Summary:

- **Total Tests Conducted**: 42
- **Tests Passed**: 40
- **Tests Failed**: 2
- **Success Rate**: 95.2%
- **Minor Issues**: 2 (Duplicate element handling & Large dataset performance)

The software demonstrates robust functionality and data handling across all core features and AI integration.

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## Test Methodology

### Testing Approach:

- **Black Box Testing**: Functional testing from user perspective
- **Boundary Testing**: Edge cases and data limits
- **Integration Testing**: Component interaction validation
- **Performance Testing**: Response times and memory usage
- **User Acceptance Testing**: Real-world geological scenarios

### Test Data:

- **Demo Dataset**: Built-in sample data

- **Synthetic Data**: Generated test datasets with known properties
- **Real-world Data**: Anonymised mining project data
- **Edge Case Data**: Malformed and boundary condition datasets

### Test Environment:

- **Platform**: Web-based application
- **Browsers**: Chrome 120+, Firefox 121+, Safari 17+
- **Operating Systems**: Windows 11, macOS 14, Ubuntu 22.04
- **Network**: Broadband internet connection

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## Detailed Test Cases

### Category 1: Data Loading and Validation

| Test ID | Test Description | Test Data | Expected Result | Actual Result | Status |
|---|---|---|---|---|---|
| DL-001 | Load collar + assay data only | Collar CSV + Assay CSV | Successful load, visualisation available | Data loaded successfully, 3D view functional | ✅ PASS |
| DL-002 | Load collar + lithology data only | Collar CSV + Lithology CSV | Successful load, lithology view available | Data loaded successfully, lithology traces visible | ✅ PASS |
| DL-003 | Load complete dataset (collar + assay + lithology) | All three CSV files | Full functionality available | All features accessible, combined views working | ✅ PASS |
| DL-004 | Load demo data | Built-in demo dataset | Immediate access to all features | Demo data loads instantly, all tools functional | ✅ PASS |
| DL-005 | Handle duplicate element columns | Assay file with duplicate element columns | Error message, load failure | **FAILS AS EXPECTED** - error message displayed | ⚠️ MINOR |
| DL-006 | Load Australian State Survey format | H1000 header format | Automatic header detection | Headers correctly identified and mapped | ✅ PASS |
| DL-007 | Handle missing coordinate fields | Collar file without X/Y coordinates | Error message, guidance provided | Clear error with field mapping instructions | ✅ PASS |
| DL-009 | Handle empty files | Zero-byte CSV files | Graceful error handling | Appropriate error message, | ✅ PASS |

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|---|---|---|---|---|---|
| | | | | no system crash | |
| DL-010 | Load large dataset (>10,000 samples) | High-density drilling project | Successful load with slow performance | Loads but with noticeable delay (>30 seconds) | ⚠ MINOR |

### Category 2: 3D Visualisation and Navigation

| Test ID | Test Description | Test Data | Expected Result | Actual Result | Status |
|---|---|---|---|---|---|
| VIS-001 | Basic 3D navigation (rotate, pan, zoom) | Demo dataset | Smooth, responsive navigation | Excellent responsiveness, intuitive controls | ✅ PASS |
| VIS-002 | Grade trace visualisation | Assay data with Cu values | Colour-coded grade traces | Traces display with appropriate colour scaling | ✅ PASS |
| VIS-003 | Lithology trace display | Lithology logging data | Distinct colours for rock types | Clear colour differentiation, legend available | ✅ PASS |
| VIS-004 | Combined grade-lithology view | Complete dataset | Offset traces for clarity | Both datasets visible with clear separation | ✅ PASS |
| VIS-005 | Vertical exaggeration adjustment | Shallow drilling data | Enhanced feature visibility | Exaggeration slider works smoothly | ✅ PASS |
| VIS-006 | Drillhole filtering | Multi-hole dataset | Selected holes only displayed | Filter checkboxes function correctly | ✅ PASS |
| VIS-007 | Grade threshold filtering | Variable grade data | Dynamic grade cut-off | Slider updates display in real-time | ✅ PASS |
| VIS-008 | Export 3D visualisation | Any dataset | Downloadable HTML file | HTML file downloads and runs independently | ✅ PASS |

### Category 3: Cross-Section Analysis

| Test ID | Test Description | Test Data | Expected Result | Actual Result | Status |
|---|---|---|---|---|---|
| CS-001 | Create drill fence cross-section | Multi-hole dataset | 2D section view | Clean cross-section with drill traces | ✅ PASS |
| CS-002 | Display lithology intervals on section | Lithology data | Left-side lithology bars | Intervals correctly positioned and coloured | ✅ PASS |
| CS-003 | Show grade values on section | Assay data | Right-side grade points | Grade values appropriately scaled and positioned | ✅ PASS |

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|---|---|---|---|---|---|
| CS-004 | Section width adjustment | Scattered drillholes | Configurable capture width | Width parameter affects hole selection correctly | ✅ PASS |

### Category 4: Statistical Analysis

| Test ID | Test Description | Test Data | Expected Result | Actual Result | Status |
|---|---|---|---|---|---|
| ST-001 | Generate summary statistics | Numerical assay data | Mean, median, quartiles, etc. | Accurate statistical calculations verified | ✅ PASS |
| ST-002 | Create histograms | Element concentration data | Distribution visualisation | Histograms display with appropriate binning | ✅ PASS |
| ST-003 | Log transform toggle | Skewed distribution data | Linear/log scale switching | One-click transform works smoothly | ✅ PASS |
| ST-004 | Correlation matrix generation | Multi-element dataset | Element correlation coefficients | Matrix displays with colour coding | ✅ PASS |
| ST-005 | Scatter plot creation | Element pairs | X-Y relationship plots | Interactive scatter plots with trend lines | ✅ PASS |
| ST-006 | Swath plot analysis | Spatial dataset | Directional grade trends | E-W, N-S, and depth trends clearly shown | ✅ PASS |
| ST-007 | Box plots by lithology | Logged geological data | Grade distributions by rock type | Clear box plots with outlier identification | ✅ PASS |
| ST-008 | Significant intervals calculation | Variable grade data | Intersection reporting | Customisable parameters produce accurate results | ✅ PASS |

### Category 5: Geochemical Clustering

| Test ID | Test Description | Test Data | Expected Result | Actual Result | Status |
|---|---|---|---|---|---|
| CL-001 | K-means clustering (k=3) | Multi-element geochemistry | Three distinct clusters | Clear cluster separation in 3D space | ✅ PASS |
| CL-002 | PCA + K-means clustering | High-dimensional data | Noise-reduced clustering | Improved cluster definition vs. direct k-means | ✅ PASS |
| CL- | Optimal cluster | Unknown | Scree plot | Elbow method clearly identifies | ✅ |

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|---|---|---|---|---|---|
| 003 | determination | domain count | analysis | optimal k | PASS |
| CL-004 | Cluster validation (3D spatial) | Clustered dataset | Coherent geological shapes | Clusters form realistic geological domains | ✅ PASS |
| CL-005 | Cluster vs. lithology comparison | Logged and clustered data | Heat map correlation | Heat map shows cluster-lithology relationships | ✅ PASS |
| CL-006 | Feature selection for clustering | Raw geochemical data | Element subset selection | Interface allows easy element selection | ✅ PASS |

### Category 6: Grade Shell Generation

| Test ID | Test Description | Test Data | Expected Result | Actual Result | Status |
|---|---|---|---|---|---|
| GS-001 | Automated grade shell creation | High-grade copper data | 3D mineralisation envelope | Shell generated with realistic geometry | ✅ PASS |
| GS-002 | PCA-based anisotropy detection | Oriented mineralisation | Automatic strike/dip determination | Orientation matches geological expectations | ✅ PASS |
| GS-003 | Dynamic cut-off adjustment | Variable grade data | Real-time shell modification | Opacity and cut-off sliders work smoothly | ✅ PASS |
| GS-004 | RBF interpolation accuracy | Sparse drilling data | Geologically reasonable interpolation | Shell honours data points and geological trends | ✅ PASS |

### Category 7: 3D Solid Model Generation

| Test ID | Test Description | Test Data | Expected Result | Actual Result | Status |
|---|---|---|---|---|---|
| SM-001 | Lithology solid generation | Logged rock types | 3D geological units | Distinct solids for each lithology | ✅ PASS |
| SM-002 | Cluster domain solids | Geochemical clusters | Domain-based 3D models | Solids reflect cluster geometry | ✅ PASS |
| SM-003 | Multiple unit selection | Multi-lithology dataset | Selected units only | Interface allows unit selection | ✅ PASS |
| SM-004 | Drillhole validation overlay | Any solid model | Original intervals visible | Colour-coded validation traces displayed | ✅ PASS |

### Category 8: Anomaly Detection

| Test ID | Test Description | Test Data | Expected Result | Actual Result | Status |
|---|---|---|---|---|---|
| AD-001 | Autoencoder training | "Normal" baseline data | Model learns geochemical signature | Training completes without errors | ✅ PASS |
| AD-002 | Anomaly score calculation | Full dataset | Anomaly scores for all samples | Scores calculated and displayed in 3D | ✅ PASS |
| AD-003 | Spatial anomaly validation | Anomalous samples | Coherent spatial patterns | Anomalies show geological significance | ✅ PASS |

### Category 9: SHAP Analysis

| Test ID | Test Description | Test Data | Expected Result | Actual Result | Status |
|---|---|---|---|---|---|
| SH-001 | RandomForest model training | Multi-element dataset | Automated model creation | Model trains successfully for target element | ✅ PASS |
| SH-002 | SHAP value calculation | Trained model | Feature importance quantification | SHAP values calculated for all features | ✅ PASS |
| SH-003 | Summary bar plot generation | SHAP results | Feature importance ranking | Clear bar plot with ranked features | ✅ PASS |
| SH-004 | Beeswarm plot creation | SHAP results | Detailed feature impact visualisation | Comprehensive beeswarm plot with value relationships | ✅ PASS |

### Category 10: AI Features

| Test ID | Test Description | Test Data | Expected Result | Actual Result | Status |
|---|---|---|---|---|---|
| AI-001 | Google API key integration | Valid API key | Successful authentication | API key accepted, AI features enabled | ✅ PASS |
| AI-002 | Geological summary generation | Complete analysis results | Comprehensive interpretation | Detailed, contextually relevant summary | ✅ PASS |
| AI-003 | Natural language data queries | "Average gold grade in andesite" | Accurate statistical response | Correct calculation with clear explanation | ✅ PASS |
| AI- | Code generation for | "Plot histogram of copper | Python code + | Code generated and executed | ✅ |

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|---|---|---|---|---|---|
| 004 | visualisation | values" | plot generation | successfully | PASS |
| AI-005 | Follow-up question handling | Previous AI conversation | Contextual responses | AI maintains conversation context effectively | ✅ PASS |

### Category 11: Data Export and Integration

| Test ID | Test Description | Test Data | Expected Result | Actual Result | Status |
|---|---|---|---|---|---|
| EX-001 | Export data | Processed dataset | CSV file download | Clean CSV with composited intervals | ✅ PASS |
| EX-002 | Export cluster assignments | Clustered data | Data with cluster labels | Additional column with cluster IDs | ✅ PASS |
| EX-003 | Export significant intervals | Intersection results | Formatted reporting table | Professional table ready for reports | ✅ PASS |
| EX-004 | Export 3D visualisations | Any 3D plot | Standalone HTML file | Interactive HTML runs in any browser | ✅ PASS |

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## Failed Test Analysis

### Minor Issue: DL-005 (Duplicate Elements)

**Issue**: Software rejects files with duplicate element columns
**Impact**: This is actually expected behaviour - the system validates data integrity
**Resolution**: Working as designed - users receive error messages and guidance. Data should be formatted prior to loading.

### Minor Issue: DL-010 (Large Dataset Performance)

**Issue**: Loading datasets >10,000 samples takes >30 seconds
**Impact**: User experience degradation for large projects
**Recommendation**: The tool is designed for modest drilling programmes bit the code may be optimised for larger datasets in the future.

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## Performance Metrics

| Metric | Target | Achieved | Status |
|---|---|---|---|
| Page Load Time | <5 seconds | Yes | ✅ PASS |
| 3D Render Time (1000 samples) | <5 seconds | Yes | ✅ PASS |
| Statistical Analysis Time | <10 seconds | Yes | ✅ PASS |
| Clustering Analysis (5000 samples) | <30 seconds | Yes | ✅ PASS |

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|---|---|---|---|
| Memory Usage (typical dataset) | <512MB | Yes | ✅ PASS |
| Browser Compatibility | Chrome, Firefox and Edge | Yes | ✅ PASS |

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## Conclusion

GeoInsights 3D demonstrates acceptable functionality across all core features with a 95.2% test pass rate. The software successfully handles standard geological workflows, provides innovative AI-powered analysis capabilities, and maintains robust data validation. The identified issues are minor and do not impact core functionality.

The AI integration represents a novel approach to geological data analysis tools, providing both traditional statistical analysis and cutting-edge machine learning capabilities in an accessible web-based platform.