NOVEL VOLUMETRIC CAVE MAPPING PROCESS UTILIZING EXISTING TECHNOLOGIES.

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Introduction: Traditional cave survey techniques using mechanical instruments and hand-drawn maps are not designed to capture accurate measurement of cave volume or three-dimensional shape [1], and attempts to interpolate 3D data from existing surveys are cumbersome and incomplete [2]. Experimental uses of LIDAR or SONAR workflows are expensive and unreliable in their current prototypical stages [3, 4]. A novel technique for mapping caves was developed specifically with volume assessment and 3D visualization in mind, using "off-the-shelf" hardware and software, adapted for field work in harsh environments, and requiring minimal training. This simplified technique, building on earlier attempts [5, 6], has immediate potential for terrestrial cave studies and implications for planetary and lunar in-cave survey by future astronauts and/or robots.

Materials and Methods: Standard cave survey instruments, e.g. compass and inclinometer, are augmented with laser distometers, a protractor plate mounted on a collapsible meter pole, and specially-designed survey notebook page templates.

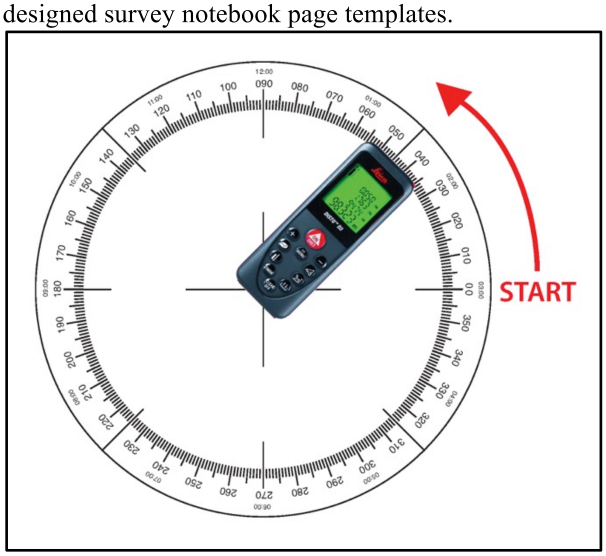

Figure 1: Laser disto and protractor plate.

Survey readings are taken radially, capturing cross-section shape, at regular intervals along the cave length, by teams of two to three technicians.

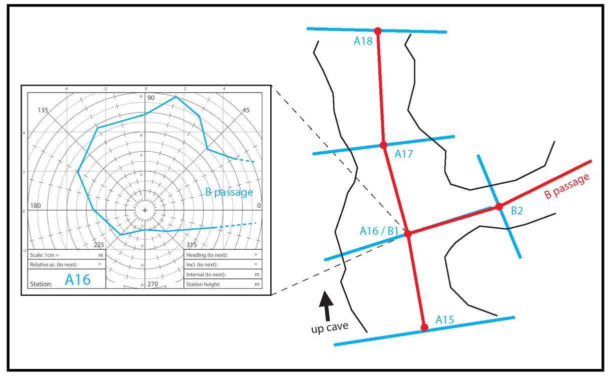

Figure 2: Sample cross-section and line plot.

Data is entered into Compass cave survey software and/or custom Excel spreadsheets for volume calculation and 3D shapefile creation. Compass data can then be exported to other GIS programs and 2D drawing programs to create maps placed geospatially.

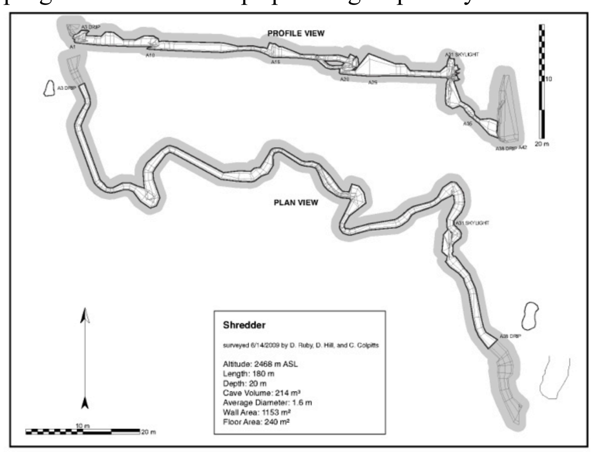

Figure 3: 2D map generated from Compass data of Shredder Cave, Atacama Desert, Chile.

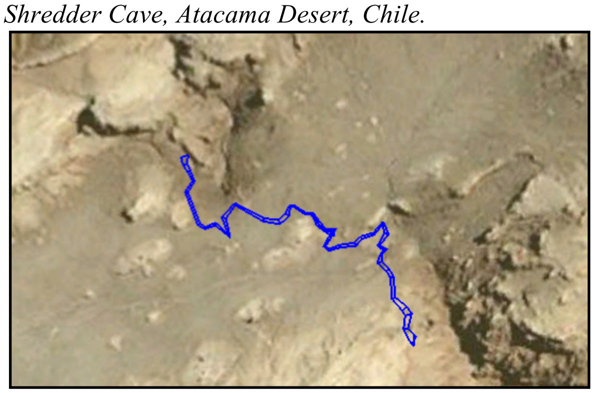

Figure 4: 3D Compass export to Google Earth, of Shredder Cave, Atacama Desert, Chile.

Discussion: This method offers some distinct advantages over existing methods, but also presents some challenges when considering planetary and lunar applications.

Advantages. The short regular intervals offer a higher resolution of data than traditional methods. A 1-meter elevated centerline buffers instruments from magnetic anomalies in cave walls. Taking eight radial measurements at each station gains accuracy over the standard four directional measurements (LRUD). This method does not depend on atmospheric flow monitoring, which has been previously proposed to estimate volume [7]. Finally, this method offers the opportunity for near-realtime field data analysis.

Disadvantages. This method relies currently on magnetic sensors for azimuth collection, which prohibits planetary or lunar implementation. This method is best suited for horizontal cave sites (e.g. lava tubes).

Proposed Modifications: Future improvements include developing an AutoCAD-based system for 3D map generation through assembly of cross-sectional profiles along the survey plot, applying interpolation algorithims between sampling stations to estimate cave volume with higher accuracy, and incorporating digital instrument platforms with limited automation.

Conclusion: This technique for measuring cave volume and creating 3D models is useful for terrestrial cave studies of thermal behavior and habitability of micro-environments, and provides considerations for future automation and planetary cave exploration as an inexpensive and reliable basis for instrument design.

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