INTEGRATING DIFFERENTIAL GEOMETRY INTO THE STRUCTURAL GEOLOGY CURRICULUM

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We recommend that undergraduate and graduate-level courses in structural geology include lectures and practical exercises that demonstrate the utility of differential geometry in field work and structural analysis. Differential geometry provides the mathematical constructs to characterize three-dimensional geological structures using well-defined geometric parameters that can be used in continuum mechanical models of tectonic processes.

Geological structures are classified as one dimensional, that is ‘linear’ (e.g. slickenlines and metamorphic lineations), or two dimensional, that is ‘planar’ (e.g. sedimentary bedding, faults, and metamorphic foliations), but structures are inherently three-dimensional. Differential geometry includes the analytical study of curves and surfaces in three-dimensional space using vector calculus and enables one to describe the departure of geological lineations from a straight line and geological surfaces from a plane.

The classical procedure of plotting attitudes (trend & plunge; strike & dip) on stereographic projections permits one to compare orientations of structures at discrete points, but ignores the fact that structures are locally continuous curves and surfaces. While serving a useful purpose, stereographic projections are inadequate for many applications because they lack the spatial information necessary to characterize the geometry of three-dimensional structures. Differential geometry provides the tools for the analysis of the spatial variation of geological structures.

As concrete examples to be used in the classroom we show how to analyze data sets from a field study, a physical model experiment, a mathematical model experiment, and a 3D seismic survey using differential geometry to characterize the shapes of folds in sedimentary rock. The folds are described by the two fundamental forms of differential geometry, and the unit normal vectors and principal normal curvatures are calculated from them. We show how incorporating the elementary concepts of differential geometry in the teaching of structural geology provides a good starting point for productive discussions of the geometries and the origins of geological structures.