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A 3D view of fold geometry

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Existing techniques for describing the shape of folded layers have been strongly influenced by the needs of the field geologist. Since outcrops rarely reveal the 3D form of the structure, these techniques are generally biased towards the 2D views (cross-sections and maps. However, new mapping methods such as seismic and GPS yield more complete 3D data, making it necessary to devise new strategies for describing fold geometry. To achieve this, use is made of the concepts of differential geometry, especially curvature. For example, new proposals are made for defining the boundaries between adjacent folds using curves on the folded surface joining points of zero mean curvature. This curve separates antiformal and synformal regions. Using curves of zero Gaussian curvature these regions can be subdivided into anticlastic and synclastic parts resulting in four fundamental classes of folds. Rules apply to the permissible arrangement of the four fold types across a folded surface. Certain fold types cannot exist as immediate neighbors, except at special points called flat points which provide a meeting point of all four fold types. In theoretical refolded surfaces, it is observed that the direction of fold boundaries is parallel to the trend of the two separate fold sets. The term fold axis is an existing one that is applicable to cylindrical folds and refers to the generator of such surfaces. For more general fold shapes, the closest equivalent concept is the line of principal curvature line of absolute minimum magnitude. These lines display remarkable patterns in natural folds, including abrupt changes in direction at fold boundaries of zero mean curvature and swerving patterns around umbilical points, i.e. points where the principal curvatures are equal. There still remain several problems, e.g. finding a practical definition of fold hinge line. In spite of these unresolved issues, numerous potential applications of the new 3D scheme exist. These include the characterization of en echelon fold systems, and the assessment of the

degree of harmony between folds developed at different structural levels.