Constraining Balanced Cross Sections in Foreland Fold and Thrust Belts

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Introduction

The primary objective of this project was to use geophysical and detailed structural studies to provide control in the construction of structural cross sections drawn across the foreland fold and thrust belt of the Central Appalachians. Twelve students from five colleges in the Keck Consortium participated in the project. Field work was conducted in central Virginia during June and July of 1993. Sam Root of the College of Wooster, Glenn Kroeger of Trinity College, and Edgar Spencer of Washington and Lee University assisted the students in their field studies, and Rick Hazlett of Pomona College visited the project.

Balanced Cross-sections

A balanced cross section is a structural cross section which is consistent with and can be restored to its predeformation state. Such sections have the following characteristics: the length of beds shown in the cross section are the same as the bed lengths before deformation, the area of units shown in the cross section is the same as their area in the restored, undeformed section, and the structural styles shown in the cross section are the same as those present in the region represented in the cross section. Ideally such sections are long and are drawn from an area outside the zone of deformation into the belt of folds and faults.

Construction of balanced cross sections involves selection of a line (usually one drawn perpendicular to structural trends), compilation of stratigraphic data--especially unit thicknesses--along the line of section, identification of "structural" units which can be characterized in terms of their mechanical properties and the types of structural features formed within them, plotting of structural and stratigraphic data along the line of the section, projecting the unit boundaries to depth and checking the cross-section for balance.

Problems with Balanced Cross Sections

In recent years, many of the cross sections found in published articles are described as balanced sections and are constructed in accordance with the techniques described by Dahlstrom (1969), Elliott (1983), Suppe (1983) and Woodward, Boyer, and Suppe (1985). It is relatively easy to check a cross section for balance using modern computer graphics capabilities or older planimeters. However, balanced cross sections are not necessarily correct representations of subsurface conditions. The sections are no better than the data and assumptions used in their construction. Problems commonly arise from inadequate knowledge of such basic information as the depth to basement, involvement of the basement in the structures, thickness of stratigraphic units and variations in thickness of units along the line of the section, and style of deformation present within units. Shortening may be caused in a number of ways ranging from folding and faulting in some beds to thickening in others. Problems may also derive from failure to project the line of the cross section outside the zone of deformation.

Regional Geological Setting

The Appalachian Mountain system is subdivided into northern, central, and southern parts. The southern and central portions of the Appalachians are composed of four morpho-tectonic provinces each of which extends northeast-southwest along the trend of the orogen. Each province is characterized by distinctive physiography which is closely related to both bedrock structure and composition of stratigraphic units. From the hinterland to the foreland of the Southern and Central Appalachians, these provinces are the Piedmont, Blue Ridge, Valley and Ridge, and Appalachian Plateau. The Piedmont and Blue Ridge are composed mainly of igneous and metamorphic rocks some of which were metamorphosed long before the beginning of Appalachian orogenesis. The unmetamorphosed sedimentary cover on this crystalline basement is exposed in the Valley and Ridge and Appalachian Plateau provinces. Deformation in the foreland is ascribed to the terminal Paleozoic Alleghanian Orogeny.

Student projects involved examination of the structure of portions of the Blue Ridge and Valley and Ridge near the southern end of the Central Appalachians. Three of the of these projects involved use of magnetic surveys to identify iron-bearing units, especially dikes in the Precambrian basement gneisses, and volcanics and iron-cemented sandstones in the sedimentary and volcanic cover on the Precambrian crystalline basement. This cover is composed of the Catoctin Formation which contains greenstones, iron-cemented sandstones and arkosic conglomerates. Four of the projects involved search for gravity anomalies which may be related to faults that displace and duplicate portions of the thick section of Cambro-Ordovician carbonates found in the Great Valley segment of the Valley and Ridge. Five of the projects involved studies of mesoscopic structural features in the Cambrian through Devonian part of the stratigraphic section in the Valley and Ridge Province.

Constraints Used in This Project

Several different types of studies, all of which bear on the accurate construction of cross sections, were undertaken in this project. Chris Blakely of Trinity, Ann Johnson of Pomona, Bill Nashem of Whitman, and Chris Titzel of Wooster with direction from Glenn Kroeger made gravity surveys along traverses across the flank of the Blue Ridge and across the Pulaski fault and related folds in the Great Valley of Virginia. Polly Hanson of Smith, Brannon Ketcham of Pomona, and Binky Parkins of Washington and Lee made surveys of total magnetic field strength in an effort to see if magnetic surveys could be used to identify rock unit boundaries in areas of poor exposure and to model subsurface configurations of some some of the rock units in the Blue Ridge. Luke Blair of Wooster, Andrew Bradford of Colorado College, Evan Howe of Colorado College, Rebecca Lesher of Whitman, and John Neill of Whitman made detailed structural measurements along three lines of section across the Blue Ridge flank, the central part of the Valley of Virginia, and the first ridges of the Valley and Ridge province to determine amount and style of shortening.

References Cited

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