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Large-Scale structural map of the Cape Fold Belt derived by remote sensing analysis

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ABSTRACT

The presented map shows the geology and structure of the Cape Fold Belt at a scale of 1:600,000. This map was produced to analyze fold structures and fault lineament trends to propose distinct structural domains within the Cape Fold Belt. This map is a first attempt to provide a coherent regional framework into which regional studies could be integrated to link the structures of the Cape Fold Belt to the structures of Gondwanide Fold Belts in South America and Antarctica. Data from Landsat-7, ASTER, SRTM and Air Photos provided the image base for an estimation of fold plunge data (azimuth and dip) and fault lineament data that were correlated with field measurements for accuracy assessment.
The map shows that the Cape Fold Belt can be subdivided into six major structural domains.
The two structural blocks in the Western Cape Province, separated by the Worcester Fault, show great similarities in fold plunge data.
However, more detailed structural data from the field are necessary to characterize the proposed structural domains and to quantify the structural blocks north and south of the Worcester Fault in greater detail.

Key words: Cape Fold Belt, structural map, fold plunge data, structural domains, remote sensing.

INTRODUCTION

The Cape Fold Belt (CFB), situated at the southernmost margin of Africa, is a well-exposed Fold and Thrust Belt. The CFB consists of three structural provinces, a northern branch from Vanrhynsdorp to Ceres, a Syntaxis around Worcester, and a southern branch from Touwsrivier to Port Elizabeth. This complex structural framework lacks fully integrated studies, which is the reason why the structural evolution of the CFB is still a matter of considerable debate (de Beer, 1992; de Wit and Ranome, 1992;Ransome and de Wit, 1992; Söhnge and Hälbich, 1983).

A new structural map presented here was produced as part of a diplom-thesis in which the system of large scale fold-structures in the CFB was reviewed (Mielke, 2008). It is an attempt to provide a coherent regional framework within which regional studies could be integrated in order to link the structures of the CFB to the structures of the Ventana Fold Belt in South America, the Ellsworth Mountains Fold Belt and the Pensacola Mountains Fold Belt in Antarctica.

METHODS

Remote sensing data from Landsat-7, the Shuttle Radar Topographic Mission (SRTM), Air Photos and the Advanced Spacebourne Thermal Emission and Reflection Radiometer (ASTER) were used to produce an image from which to estimate fold plunge data (Figure 1).
Further structural data were correlated with field data from test areas in the Syntaxis, in the great Swartberg Range and around Uniondale. Correlation of the estimated plunge azimuth and dip with field measurements of fold plunge data showed that accuracy of estimated values is above 95% for fold plunge azimuths, and over 68% for the estimated dip values. Fault lines were identified from Landsat-7 data in addition to data from geological maps at a scale of 1:250,000 from the Council for Geoscience, which provided the geological overlay. The shaded background information represents calculated surface roughness data according to the method presented by Formento-Trigilio et al. (1998), from SRTM elevation data-sets. SRTM data and Landsat-7 data are provided by the Global Landcover facility, hosted by NASA and the University of Maryland.

RESULTS

The topography of the CFB reflects a lot of its geological structure because of the alternating beds of soft shales, sandstones and hard quartzites. Sandstone and quartzite crop out as resistant cliffs with a low dimensionless surface roughness number (high surface roughness). In contrast, numerous soft shale beds, which are more prone to erosion, show high dimensionless surface roughness numbers (low surface roughness). These two properties act as a morphologic and structural “edge-enhancement filter” mimicking the large-scale folds and faults in the southern and north branches of the CFB.

With the help of these simple tools at least six structural domains in the CFB can be identified from the structural map (Figure 1). The six structural domains are relatively homogenous with respect fold plunge data and fault lineaments.
is characterized by shallow SE trending plunge azimuths. The Port Elisabeth Antitaxis is dominated by ESE trending fold plunge data steeper than 8°. The Southern limb is dominated by a general E-W trend that gradually joins the NE plunge azimuth trend of the Syntaxis and shallows in plunge dip towards the Escarpment Foreland domain. Fold plunges in the Northern limb are directed towards the SSE. However, further characterization of the structural domains is necessary to assess the different structural models of the CFB (Johnston, 2000), (Ransome and de Wit, 1992) , (Söhnge and Hälbich, 1983).

The two structural blocks in the Western Cape Province that are separated by the Worcester fault show great similarities in fold plunge data. More structural data between Cape Town and Vanrhynsdorp, and between Hermanus and Mosselbaai are needed for a detailed study and comparison of the structural blocks north and south of the Worcester fault. Additionally, two perpendicular, major fault-lineament trends (NW- SE and NE-SW) can be observed throughout the CFB (Figure 2). These trends were already reported by de Beer (1992) as he described the Syntaxis.

Active faults are clearly enhanced by the surface roughness calculation, for example between Laingsburg and Oudtshoorn.

The large-scale structural map of the Cape Fold is a first attempt to establish a CFB wide framework into which regional mapping results could be integrated. The resulting structural observations could be more easily used to make correlations to the structure of the Ventana Fold Belt in South America and the mountain ranges in Antarctica (e.g. Ellsworth Mountains Fold Belt and Pensacola Mountains Fold Belt).

Far more detailed work on the CFB needs to be done to understand the structural evolution of this worldwide remarkable Fold Belt.

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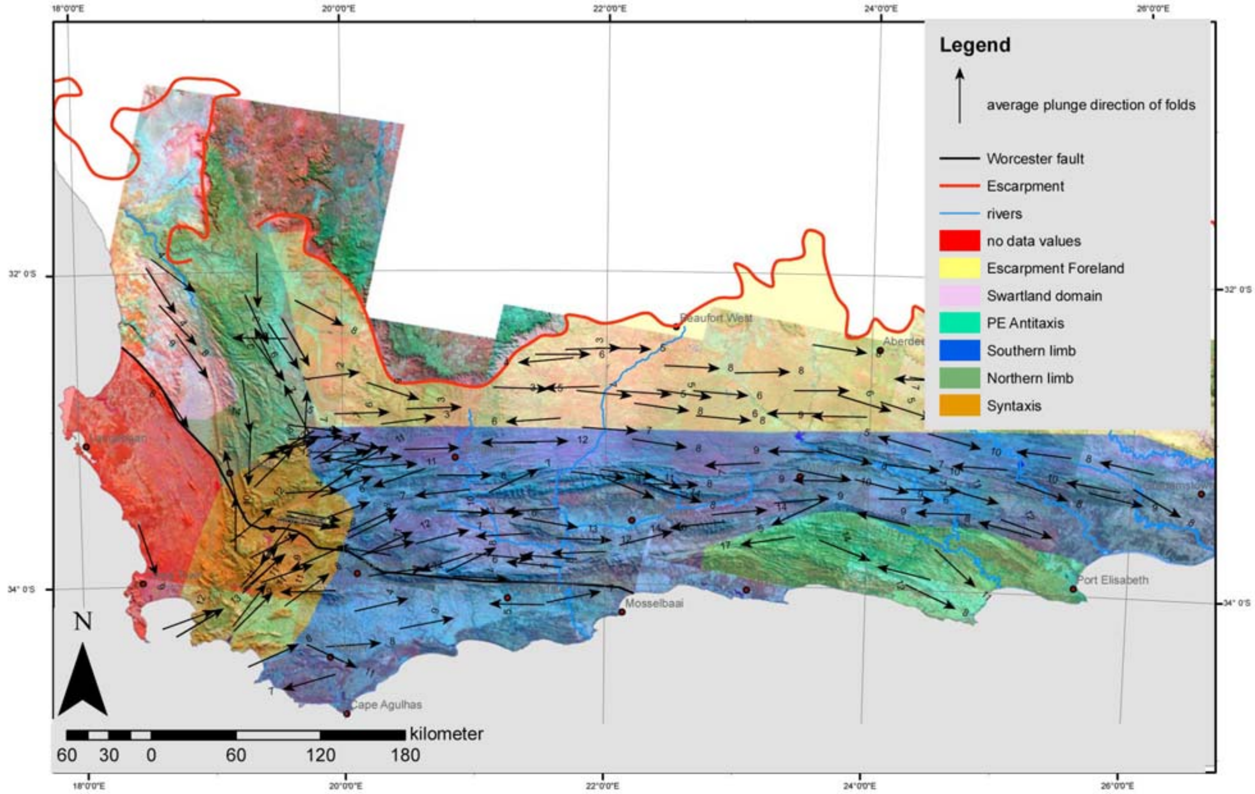

Figure 1. Proposed structural domains in the Cape Fold Belt, based on an analysis of the large-scale structural map of the Cape Fold Belt. Black arrows show the average plunge direction of large-scale folds. The background image shows a mosaic of Landsat-7 bands (7,4,2) to enhance the view of the structural trend that is given by the average plunge arrows.

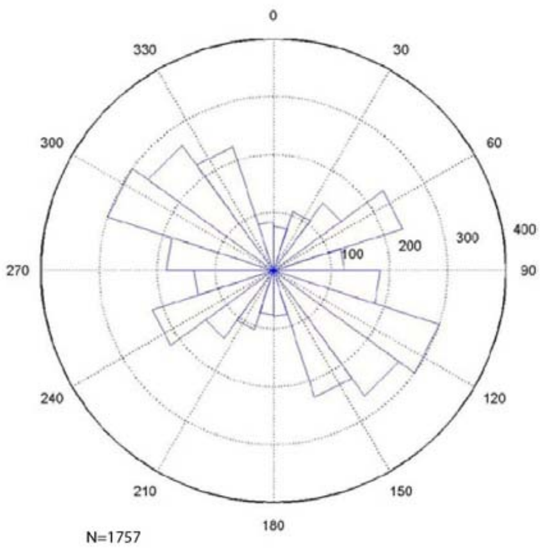

Figure 2. Fault lineament trend across all structural domains of the Cape Fold Belt. Note the major NW-SE trend and the minor NE-SW trend.