Constraining the timing of deformation band formation using relative timing, burial history modeling, and cement stratigraphy, Seiyal Fault, Western Desert, Egypt

By Steven Gohlke

I. Introduction

This is a progress report on thesis research approved in April 2012. The purpose of this study, part of a larger project known as Desert Eyes, is to constrain the timing of deformation band formation on a NE-SW striking fault splay of the E-W striking Seiyal Fault (**Figs. 1a**, **1b**). These strike-slip faults cut a structural dome (500 m by 1,000 m) consisting of shallowly dipping Cretaceous sandstone (**Figs. 1b**, **2a**). This research examines deformation bands and calcite veins within the Seiyal Fault splay damage zone in order to determine their relative timing and relationship to tectonic events affecting southern Egypt since the Late Cretaceous. Cataclastic deformation bands are associated with faulting in porous rocks, such as the field area's Taref Member of the Nubian Sandstone (**Fig. 2c**), and form between 1.5 and 2.5 km depth (Fossen, 2007).

The Desert Eyes project seeks to explain the origin of distinctive bedrock features identified on satellite imagery in southern Egypt (Tewksbury et al., 2009). Desert Eyes are structural domes and basins consisting of shallowly-dipping bedding in sedimentary rocks, and range from hundreds of meters to kilometers in diameter (See **Fig. 1b**). The most recent satellite imagery has increased resolution to 1 m^2/pixel, allowing mapping of these structures via remote sensing, because many areas of interest are too remote to conduct field work in. Therefore, the research conducted on the Seiyal Fault will be the basis for further work on Desert Eyes found in younger Eocene rocks to the west on the Sinn el-Kaddab Plateau (**Fig. 1a**). Two well-documented tectonic events affected southern Egypt after the Coniacian-age (89.3-85.8 Ma) Taref Member and Early Eocene sequences were deposited, one in the Late Cretaceous and another in the Late Eocene, (Issawi, 1968; Issawi, 1999; Guiraud et al., 2001). Distinguishing

Cretaceous from Eocene deformation is the ultimate goal of this project, which will make clear the timing of folding, deformation band formation, faulting, and calcite veining in the field area.

The thickness, age, and lithology of previously overlying rock formations will be combined in order to construct a burial history model for the Taref Member. This model will constrain the timing of deformation band formation by identifying the timing of tectonic events responsible for deforming it. Since deformation bands and cementation occur within restricted depth ranges, burial history modeling can be used to infer the periods of time during which these features developed.

II. Completed Work

Field data on the abundance (per square meter) and orientation of deformation bands and calcite veins were collected 70 km SW of Aswan in January 2012. These data were focused in three sampling grids along the Seiyal Fault splay (**Figs. 1c**, **1d**). The use of grids and transects has been successfully employed by many studies to quantify occurrences of deformation bands (e.g. Aydin & Johnson, 1978; Antonellini & Aydin, 1994; Rotevatn et al., 2008; Solum et al., 2008; Eichhubl et al., 2009). Samples were taken on the Seiyal Fault splay rather than the main strand of the fault itself due to the lack of consistent exposure. The data indicate that deformation band abundance decreases from 6.4 m^{-2} at the center of the fault damage zone to 1.1 m^{-2} at its edge 30 m away. Over the same distance, the mean variance of deformation band orientation (the difference between the deformation band and fault plane orientation) increases slightly by 5.4^0, from 42.2^0 to 47.6^0 (**Fig. 3**). While deformation band abundance and orientation change with increasing distance from the center of the fault damage zone, calcite veins do not show a similar pattern. They take on a variety of orientations and are widely distributed over the field area.

Micro-scale observations are also being used to address the research goal. For example, in thin section calcite veins frequently cut across deformation bands. Preliminary SEM/CL results show that an early cement generation of quartz is cut by deformation bands. Later post-deformation band cements observed on the eight sampled thin sections all show an identical cement stratigraphy consisting of an initial generation of microcrystalline calcite inter-grown with kaolinite and a later blocky, pore-filling calcite that is coeval with the calcite veins. SEM images were also taken of transects across the same eight deformation band thin sections at 110x magnification in order to compare deformation bands to their host rock (**Fig. 1b**). Point counts (300 points) of these transects show a decrease in mean grain size within the deformation bands ranging from 37-75% relative to the host rock.

References

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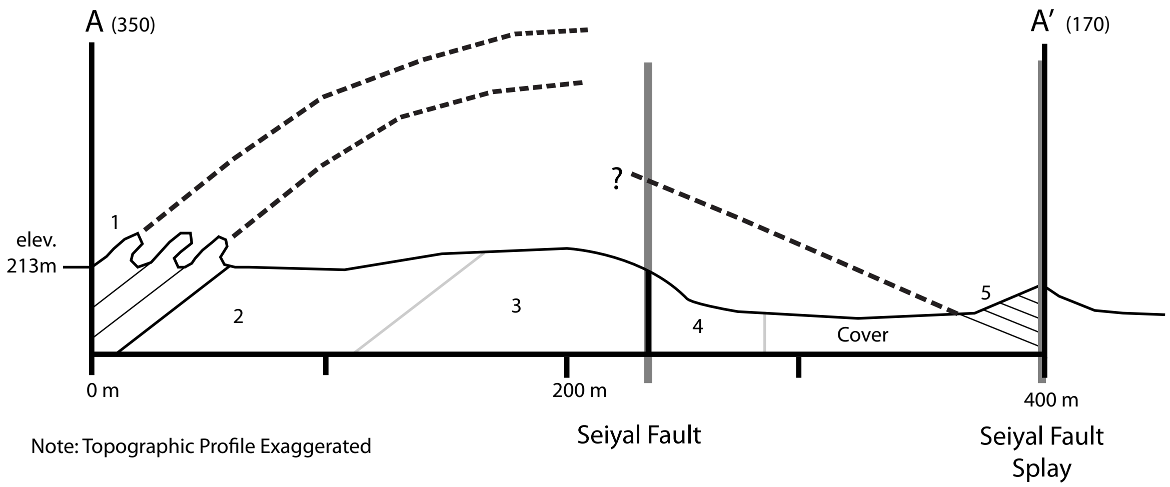
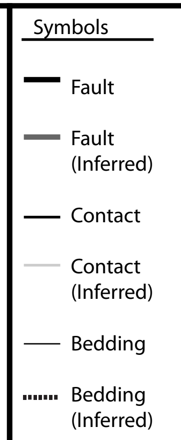
Figure 2-Cross Section of Field Area, Lithologies and Stratigraphy





Lithologies of the Field Area:

1) Marine Sandstone. Ridges of flagg

2) Massive, Crossbedded Sandstone with concretions, well cemented

3) Undetermined Sequence (possibly more fluvial). Thinly bedded (5-10cm), similar colors

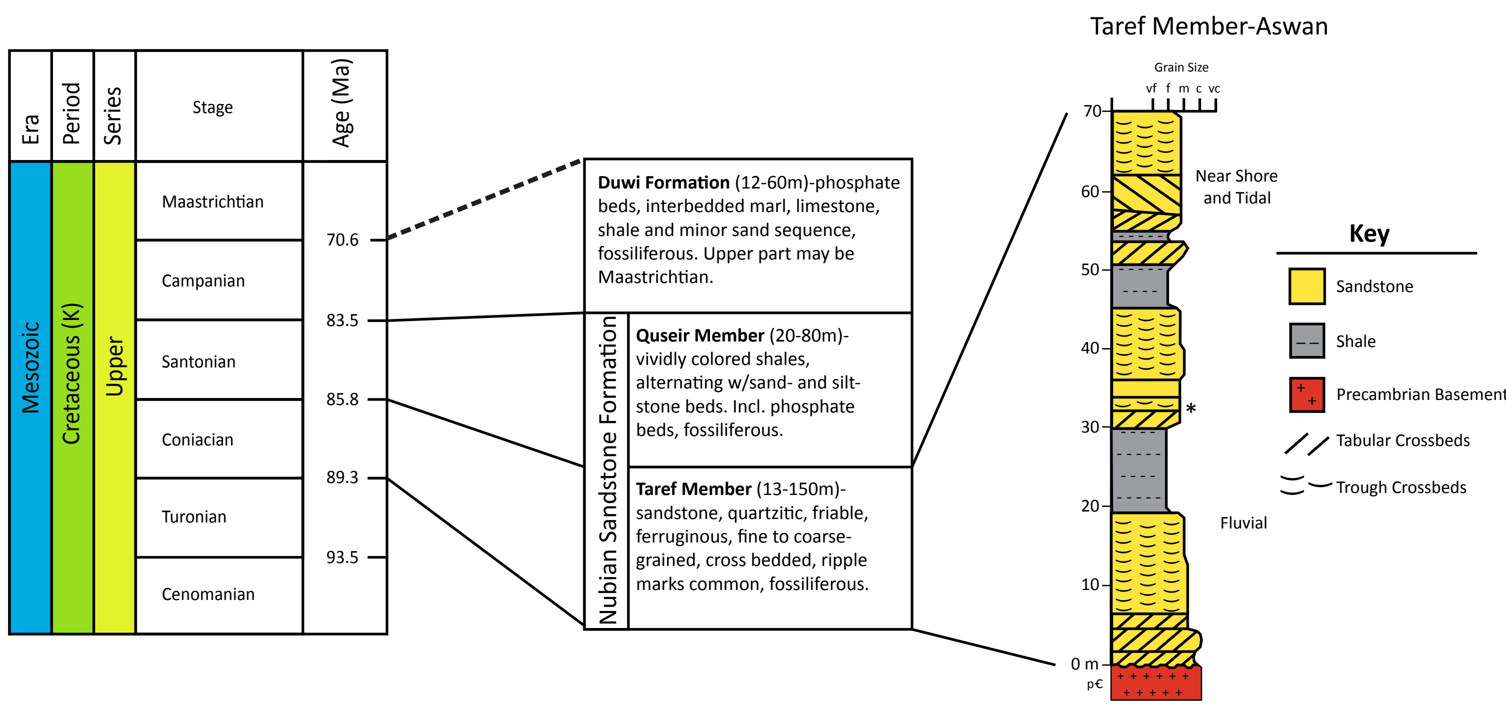
4) Friable, Crossbedded Sandstone, poorly cemented

5) Fluvial Sequence-thinly-bedded, fining upward cycles consisting of alternating sandstone, siltstone, and conglomerate with little lateral continuity.

Estimate thicknesses, refine strat position.

2a. Cross section of the Seiyal Dome, constructed using data collected in the field. Note that the Numbers indicate lithologies described.

2c. Stratigraphy of the Taref Member near Aswan showing its age, overlying rock units, and depositional sequence (*indicates stratigraphic position of the Seiyal dome within Taref Member). Based on ICS 2004 Geologic Time Scale, Issawi et al., 1999 (Table 7), Shawa & Issawi, 1978 (Figure 6).



Grid Maps of Field Data

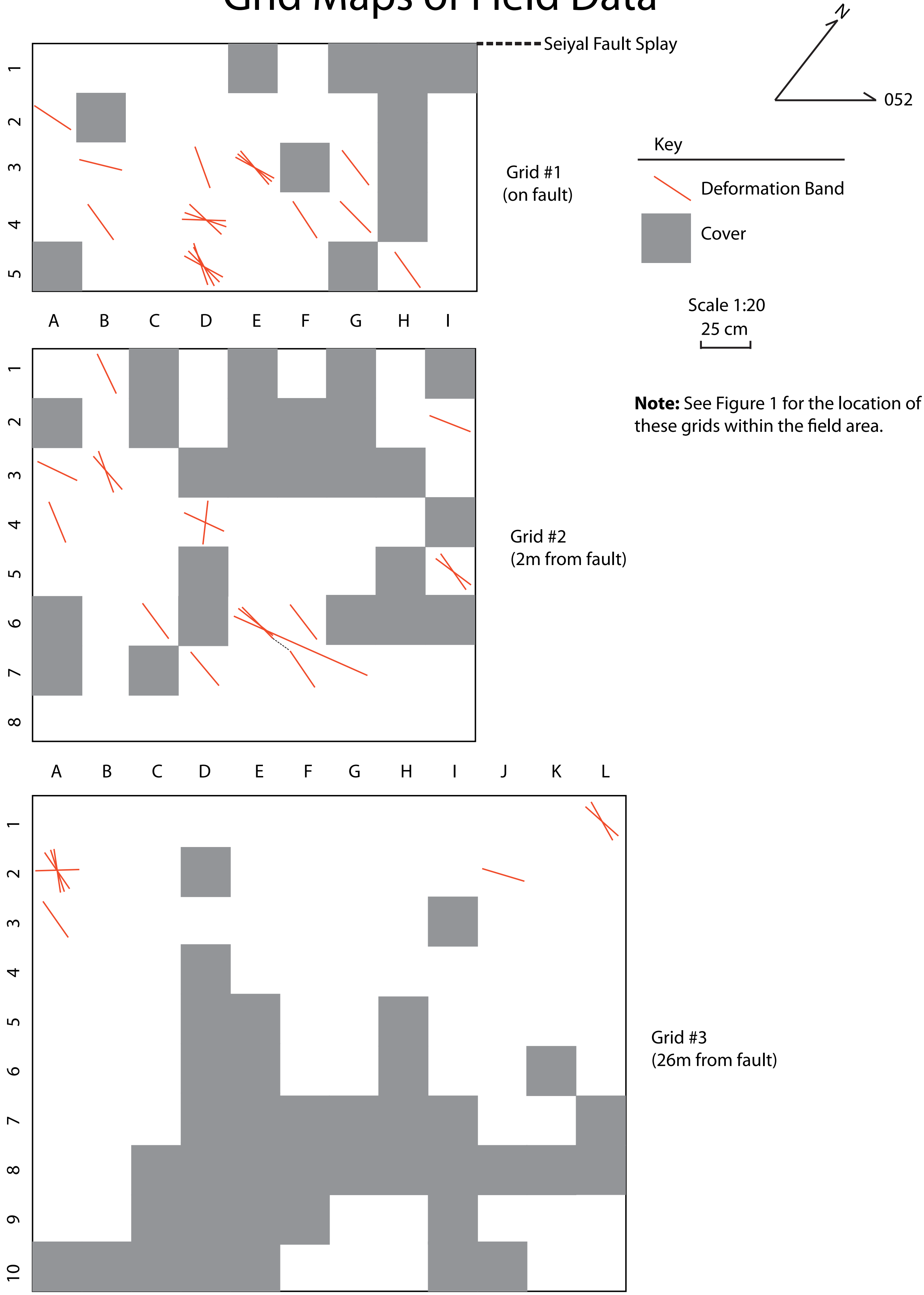
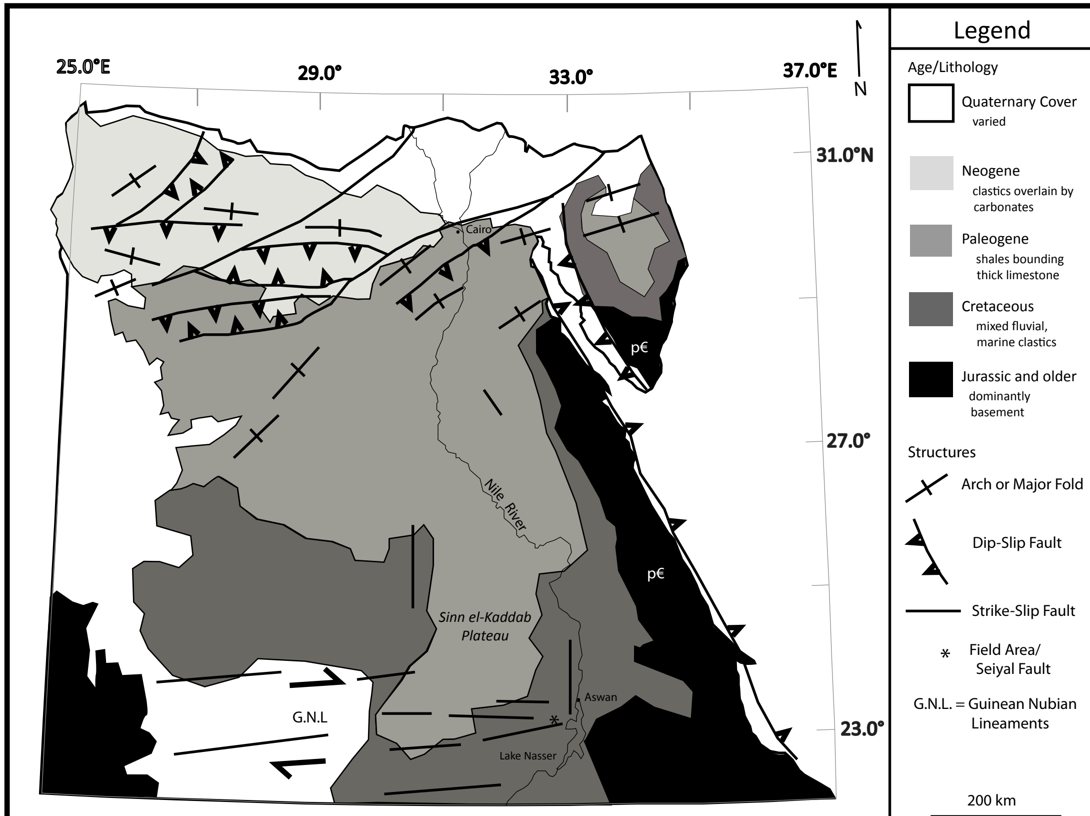
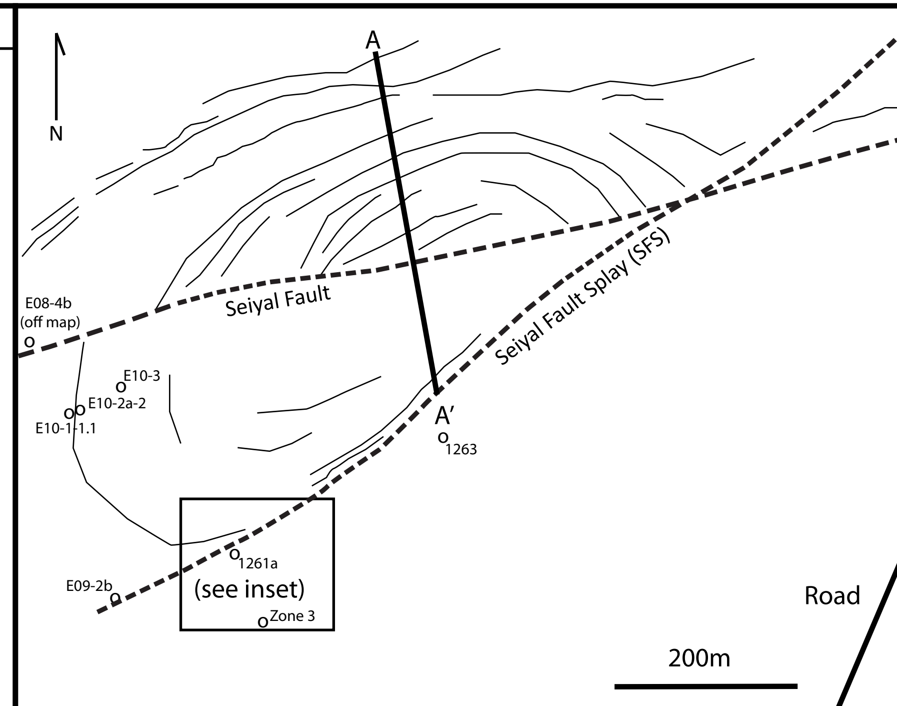


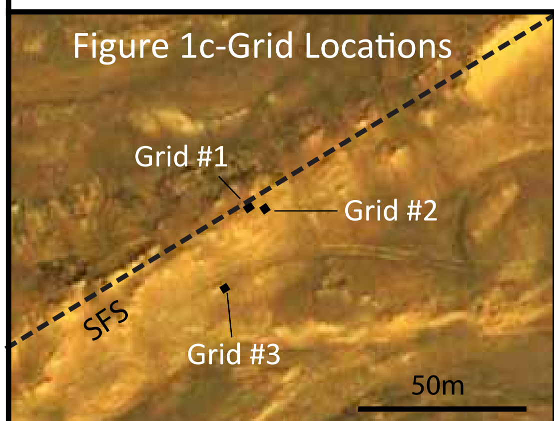
Figure 1-Geology of Egypt, Field Area, and Sample Locations



1a. Generalized Geologic Map of Egypt-*modified after Guiraid (2001), EGSMA (1981)*



1b. Map of field area, which includes the Seiyal fault, a fault splay, dome, and location of sample grids (traced from *Google Earth Pro*). Dashed lines are the fault traces, thin solid lines are beds, and o = sample location. Sample location E08-4b lies ca. 500m beyond western map boundary. See Figure 2 for Cross Section A-A'.



1c. Data on the orientation of deformation bands and sample collection was focused in three grids along the damage zone of the Seiyal Fault Splay. Satellite image from Google Earth Pro.

1d. Combined data from grids

Right: Rose diagram shows deformation band trends.

Far Right: Stereonet of poles to calcite vein orientations (right) with girdle (014/81)and principle stress axis ■ = (284/09).