FOLDING AND FAULTING INSTABILITIES IN EXTREME ELASTIC SOLIDS

***D. Bigoni*[1], *P.A.Gourgiotis* [1]**
[1]*University of Trento, Trento, Italy*

1. Extreme Cosserat materials

Extreme elastic materials are designed to work near a material instability, where they display stress channelling and strain localization, effects that can be exploited in several technologies. Extreme couple stress solids are introduced and systematically analyzed in terms of several material instability criteria: positive definiteness of the strain energy (implying uniqueness of the mixed b.v.p.), strong ellipticity (implying uniqueness of the b.v.p. with prescribed kinematics on the whole boundary), plane wave propagation, ellipticity, and the emergence of discontinuity surfaces. Several features are highlighted: (i.) Ellipticity is mainly dictated by the 'Cosserat part' of the elasticity and (ii.) its failure is shown to be related to the emergence of discontinuity surfaces; (iii.) Ellipticity and wave propagation are not interdependent conditions (so that it is possible for waves not to propagate when the material is still in the elliptic range and, in very special cases, for waves to propagate when ellipticity does not hold) [1].

The antiplane strain Green's functions for an applied concentrated force and moment are obtained for Cosserat elastic solids with extreme anisotropy and used to show that the wave propagation condition (and not ellipticity) governs the behavior of the antiplane strain Green's functions. These Green's functions are used as perturbing agents to demonstrate in an extreme material the emergence of localized (single and cross) stress channelling and the emergence of antiplane localized folding (or creasing, or weak elastostatic shock) and faulting (or elastostatic shock) of a Cosserat continuum, phenomena which remain excluded for a Cauchy elastic material. During folding some components of the displacement gradient suffer a finite jump, whereas during faulting the displacement itself displays a finite discontinuity [2].

2. Folding and faulting in plane strain

Folding is a process in which bending is localized at sharp edges separated by almost undeformed elements. This process is rarely encountered in Nature, although some exceptions can be found in unusual layered rock formations (called 'chevrons') and seashell patterns (for instance Lopha cristagalli), see Fig. 1.

In mechanics, the bending of a three-dimensional elastic solid is common (for example, in bulk wave propagation), but folding is usually not achieved. The route leading to folding is shown for an elastic solid obeying the couple-stress theory with an extreme anisotropy, a result achieved through development of two-dimensional Green's function for constrained Cosserat material [3].

Fig. 1 Chevron folds in layered rocks near Millook Haven (UK). A Lopha cristagalli seashell is shown in the inset, which clearly shows folding

3. Acknowledgement Financial support from ERC advanced grant no. FP7-PEOPLE-IDEAS-ERC-2013-AdG (2014-2019) is gratefully acknowledged.

4. References

[1] P.A. Gourgiotis, D. Bigoni (2016). Stress channelling in extreme couple-stress materials Part I: Strong ellipticity, wave propagation, ellipticity, and discontinuity relations *J. Mech. Phys. Solids*, **88**, 150-168.

[2] P.A. Gourgiotis, D. Bigoni (2016). Stress channelling in extreme couple-stress materials Part II: Localized folding vs faulting of a continuum in single and cross geometries *J. Mech. Phys. Solids*, **88**, 169-185.

[3] D. Bigoni and P.A. Gourgiotis (2016). Folding and faulting of an elastic continuum. *Proc. Royal Soc. A*, **472**, 20160018.