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When does AMS develop and register strain in extensional sedimentary basins?

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The anisotropy of magnetic susceptibility (AMS) applied to petrofabric studies of rocks has demonstrated a parallelism between the orientation of the magnetic susceptibility ellipsoid and the orientation of the strain ellipsoid. However, this relationship can be obscured because of the existence of complex magnetic fabrics (related to successive deformation phases or different magnetic mineralogies). Recent AMS studies in sedimentary rocks indicate that magnetic fabric develops at the early stages after deposition, during sediment compaction, and it registers the stress pattern acting at this moment.
This work deals with the time of locking of the primary fabric. The influence of early compactional processes such as dinosaur footprints, load structures due to differential compaction, or dish-and-flame structures associated with fluid migration related to seismites is also studied through the AMS record.
Samples were taken on marls and siltstones from the Enciso Group, in the Cameros Massif. Located in the northwesternmost part of the Iberian Range (NE Spain), this area was a strongly subsiding sedimentary basin during the Late Jurassic-Early Cretaceous, accumulating a sinrift sedimentary series with continental origin that reaches a maximum thickness of 8000m on its depocentre. The particular lithology and lacustrine sedimentary environment characteristics of the Enciso Group ensured a lot of dinosaur tracks to be preserved.
A total of 704 standard specimens from 9 compactional structures were analyzed in a KLY-3S Kappabridge (AGICO, Czech Republic) susceptometer to obtain the bulk susceptibility and the orientation of the three principal eigenvectors (kmax > kint > kmin) of the magnetic ellipsoid. In order to constraint the relative contribution of paramagnetic and ferromagnetic phases to the magnetic susceptibility, high (40-700ºC) and low (-195-0ºC) temperature susceptibility measurements were carried out, combining the susceptometer with CS3 furnace and with CLS, respectively.
The magnetic susceptibility ranges mainly between 100 and 250 x 10-6 SI. These values and the results obtained from the temperature-susceptibility measurements indicate that the paramagnetic fraction is carrying the magnetic susceptibility, showing the preferential orientation of phyllosilicates in all specimens.
In each compactional structure, specimens were taken in four areas: (i) bottom (directly affected by compression), (ii) edges (where sediment removal and flow takes place), (iii) non-deformed sediments and (iv) track infill or layer younger than those affected by differential compaction or fluid-escape structures. A reference site near every studied structure, where no early compactional processes have been recognised was also sampled.
Results show a stronger scattering of the three magnetic anisotropy axes at the edges of the structures in comparison with the other parts of the structure or the reference sites. There is also a better grouping in the bottom specimens directly affected by the track than in non-deformed specimens. However, similar scattering of axes before and after laminae restoration in the dinosaur footprints is observed. Nevertheless, there is a stronger scattering of axes before applying that laminae restoration in load and fluid-escape structures indicating that the early acquisition of the AMS orientation is disturbed by the fluid escape. In the seismite this scattering is even stronger.
We can attempt to define a sequence for the primary magnetic fabric development. Firstly, an oblate fabric was developed related to the deposition of phyllosilicates, with their minimum axis perpendicular to the bedding plane. During deposition, stretching related to extensional tectonics in the Cameros basin oriented the magnetic lineation (kmax). This early fabric was disturbed due to the generation of dinosaur footprints, sedimentary load and fluid escapes. These results indicate that the magnetic lineation related to extension in sedimentary basins can be affected by early compactional structures.