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How complex are reversals?

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Rapid changes of the geomagnetic field challenge the resolution of the best natural recorders. Volcanic records consist of snapshots of the field with gaps of unknown length between each cooling unit. Sedimentary recordings are smoothed to an unknown degree by poorly understood remanence lock-in and diagenetic magnetization processes, and hiatuses are common and often difficult to identify. Thus, paleomagnetic records should always be regarded as incomplete, giving only lower bounds on how fast and complex the field changes actually were. Geodynamo simulations provide a complementary approach to learning about field behavior during reversals, but limitations in computer power still prevent them from operating near the parameter regime appropriate for the core on geologic time scales, with concomitant loss of spatial and temporal resolution. To make progress in the face of such difficulties we need to bear these shortcomings in mind while pushing forward on all fronts.

Early sedimentary records of reversals tended to be of low resolution and fostered models characterized by simple transition paths with longitudinally confined virtual geomagnetic poles caused by decay and regeneration with opposite sign of the axial dipole in the presence of standing or zonal non-dipole fields. Virtual geomagnetic poles from transition records in lava flows showed less longitudinal confinement, and as higher resolution sedimentary records were obtained, more complex transition paths were found that include large VGP oscillations. Awareness of the potential recording problems of sediments, however, resulted in many such oscillations being dismissed as artifacts. On the other hand, some reversals exhibited by the Glatzmaier-Roberts geodynamo simulations are indeed complex, while others are quite clean and simple. In this talk we make the case that at least some polarity transitions are substantially more complex than typically portrayed, concentrating on the most recent, Matuyama-Bruhnes reversal that occurred 0.78 million years ago and on the 16.6 Ma reversal recorded in lava-flow sections at Steens Mountain, Oregon and the surrounding area.