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Paleomagnetism of the Marcellus Shale in cores from the Plateau Province of the Appalachian Basin

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An integrated paleomagnetic, magnetic fabric, and petrographic study of two cores, one oriented (EC) and one unoriented (DB), in the Marcellus Subgroup from the Plateau Province in Pennsylvania indicate the presence of multiple chemical remanent magnetizations (CRMs) and extensive alteration. Anisotropy of Magnetic Susceptibility (AMS) results indicate that DB contains a predominately oblate AMS fabric. In EC, the oblate fabric is streaked and some samples contain a prolate fabric that is interpreted as diagenetically altered. Paleomagnetic data from both cores indicate that there are multiple magnetic components. Neither core contains a well-developed viscous remanent magnetization at low temperatures (< 100°C) that could be used for orientation. Analysis of the cores indicate that the low temperature components may be contaminated by a drilling induced remanent magnetization. An intermediate temperature component (100-300°C) with steep down directions (ITN) is removed in both cores. DB also contains a component with steep up inclinations (ITR) at higher temperatures (300-400°C) that is interpreted to be a reversal of ITN. The ITN and ITR components are interpreted as late Jurassic to Cenozoic in age based on a comparison with the expected inclinations for the study location. Many specimens from both cores contain a well-defined characteristic remanent magnetization (ChRM) with shallow inclinations that is removed at temperatures between 300 -500°C in DB and 300 - 460°C in EC. The DB ChRM has an inclination of -9.0°, which corresponds to a time of acquisition between 300-310 Ma. The ChRM in the oriented EC core has streaked declinations, which may have been caused by core barrel rotation. Shallow inclinations (- 4.9°) in this core correspond to a time of acquisition of 300 Ma. Based on the demagnetization characteristics, the ITN and ITR components are interpreted to reside in pyrrhotite and magnetite whereas the ChRM is interpreted to reside in magnetite. Rock magnetic studies are consistent with this interpretation. The ITN and ITR are interpreted as CRMs. The ChRM in DB is interpreted as a CRM that resides in magnetite. Vitrinite reflectance values are higher in EC than DB, and a thermoviscous origin cannot be ruled out for the ChRM. Diagenetic studies indicate a complex paragenesis with authigenic minerals such as barite, sphalerite, baroque dolomite, and sylvite suggest alteration by external fluids and although some of minerals may have been sourced internally. The age of the characteristic CRM and its' presence in highly altered zones in both cores suggests it is related to alteration by external fluids prior to the main phase of the Alleghanian orogeny. The ITN and ITR CRMs are interpreted to be related to thermochemical sulfate reduction. The results of this study, and comparison with the results of other studies, suggest that the Marcellus Subgroup was a complex diagenetic system that was open to external fluids at some time.