Palo Duro Canyon State Park Study of Cone-shaped Iron-oxide Concretions

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Sponsor: SwRI® Advisory Committee for Research

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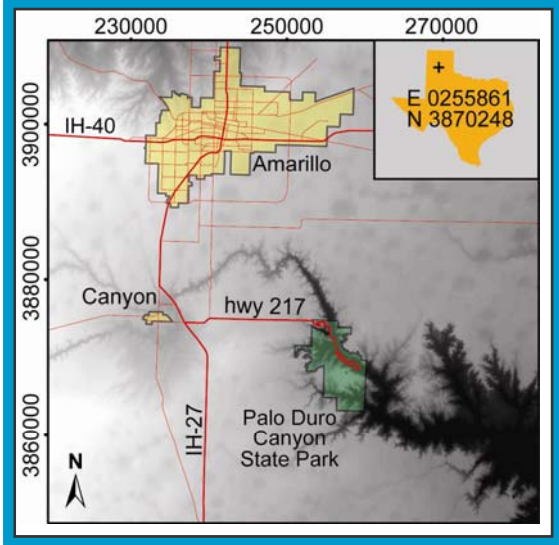

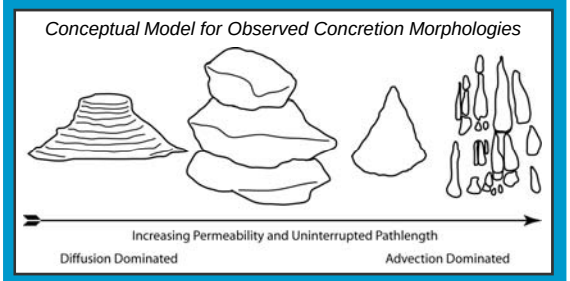

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Program Brief

Statement of Problem: Concretions commonly develop in sedimentary rock by precipitation of minerals from circulating fluids at mixing fronts. They are compositionally distinct from host rock because diagenetic mineral cement fills preexisting sediment porosity, making concretions more dense and resistant to weathering than surrounding rock. *In situ* concretions are significant because they record both historical information about past processes that occurred within the geologic unit and present-day information about the ability of the unit to conduct fluids. In effect, the mineralogy, morphology (shape), and spatial distribution of concretions can serve as controls on conceptual models for subsurface fluid flow. Unusual cone shaped iron-oxide concretions observed in seven fluvial sandstone units of the basal member of the late Triassic Trujillo Formation at Palo Duro Canyon State Park were originally documented in an unpublished paper by William Holliday, who invited PI Dinwiddie and collaborator Marjorie Chan to begin an in-depth study of controls on their occurrence.

Approach and Accomplishments: To gain familiarity with the broader geological context of these unusual concretions, especially the host rock, and develop a working hypothesis for their occurrence, this 4-month project funded preliminary field research and a supporting literature survey. Staff made first-order observations of concretion orientations, shapes, aspect ratios, and sizes, and mapped their spatial density. Staff noted the presence of pyrite pseudomorphs associated with concretions, density characteristics, and lithology-dependent morphologies.

In situ concretion orientation is cone-apex up, body radiating down and out, with long axis perpendicular to bedding. The concretions are densely mineralized at their apex, and become less densely mineralized with depth. Morphologies are associated with the sedimentary texture and primary bedding structure of the host rock; three lithofacies exhibit different cone forms. The cone shape suggests downward and laterally spreading precipitation from mineralizing fluids in the unsaturated (vadose) zone. Fluid flow in the vadose zone is generally gravity dominated, yet has a lateral component consistent with both the apex-upright cone shape of these concretions and the depth-dependent density of their mineralization. Our working hypothesis is that (1) iron pyrite cubes precipitated on organic-rich nuclei during saturated, reducing conditions; (2) hydrologic conditions shifted from saturated to unsaturated; (3) meteoric water infiltrating the vadose zone oxidized the pyrite; and (4) iron was reprecipitated as oxides to form vertically oriented cone-shaped concretions under the influence of gravity.

Client Benefits: This research strengthened a subsequent proposal to the National Science Foundation (NSF) to conduct *in situ* minipermeametry, geochemical modeling, geological mapping, and laboratory analyses of these concretions and their host rock, and also enabled preparation of a documentary manuscript now in final revision for publication in the journal *Geofluids*.

Publications and Presentations: Dinwiddie, C.L., M.A. Chan, R.N. McGinnis, and J.L. Myers. Chronicles of Vadose Zone Diagenesis: Cone-Shaped Iron-Oxide Concretions, Triassic Trujillo Formation, Palo Duro Canyon, Texas. Paper No. 147-8. *Geological Society of America Abstracts with Programs, 41*(7): 393. GSA Annual Meeting, Portland, OR, October 18–21, 2009.