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October 18, 2001
Contract No. NRC–02–97–009

U.S. Nuclear Regulatory Commission
ATTN: Mrs. Deborah A. DeMarco
Office of Nuclear Material Safety and Safeguards
Mail Stop 8 A23
Washington, DC 20555-0001

Subject: Transmission of Abstracts: (1) Relay ramp style in massive limestone: Examples from the Sierra Del Carmen (west Texas), (2) Influence of regional strains in development of fault domes in the offshore Middle East, (3) Estimation of sub-seismic-fault populations, and (4) Working for a not-for-profit research and development organization in the earth sciences.

Dear Mrs. DeMarco:

The purpose of this letter is to transmit the subject abstracts to NRC for information only. The structural concepts described in the first three abstracts resulted from work done for the Japanese National Oil Company. These concepts have given CNWRA staff a broader understanding of normal faulting processes, such as those that occurred at Yucca Mountain. These presentations will be given at the annual meeting of the American Association of Petroleum Geologists in March of 2002. The fourth presentation will be given at a special Education and Human Resources session on employment opportunities for students at the annual meeting of the American Geophysical Union in December 2001. Costs for presenting these papers will not be incurred by NRC.

Should you have any questions regarding this, please contact Dr. David Ferrill at (210) 522-6082 or Dr. Lawrence McKague at (210) 522-5183.

Sincerely,

B. Sagar
Technical Director

BS/re
Attachments

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Abstract for the American Association of Petroleum Geologists Annual Meeting, 2002

Relay ramp style in massive limestone: Examples from the Sierra Del Carmen, west Texas

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Relay ramps and breached relay ramps are important locations of enhanced fracture permeability in fractured reservoirs. The spectrum of relay ramp geometries includes relay ramps where displacement is partially accommodated by development of synthetic dip or several parallel normal faults within the relay ramp. Relay ramps that accommodate fault system displacement by development of synthetic dip or smaller scale faulting are recognizable as displacement minima on cumulative displacement profiles of the bounding faults. The Sierra Del Carmen in west Texas provides excellent exposure of a normal fault system in the thick, massive Cretaceous Santa Elena Limestone. Displacement maxima are on the order of tens to hundreds of meters and are in the size range of structures resolvable using seismic methods. Remote sensing and field analysis of the Sierra Del Carmen fault system reveals that fault linkage by connecting fault formation is rare or absent. Rather, fault linkage developed by curved lateral propagation of overlapping fault tips. Detailed analysis of relay ramps in various stages of development shows that relay ramps commonly contain smaller displacement normal faults parallel or at a low angle to the bounding faults, producing nested relay ramps. In each case, these relay ramps correspond to displacement minima on cumulative displacement profiles of the bounding faults. This relay ramp style may reflect early distributed faulting between underlapping faults. Prediction of analogous subseismic faults in production settings may be possible by identifying displacement minima on cumulative displacement profiles of seismically imaged faults.

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Influence of regional strains in the development of faulted domes in the offshore Middle East.

Many oil fields in the offshore Middle East have traps in broad domes developed over salt. A recent 3D seismic survey from a fractured Cretaceous carbonate reservoir reveals that one elliptical dome is cut by an array of parallel, NW-SE striking normal faults. We used clay cake models to simulate development of the fault pattern and to understand its relationship to dome shape, stress regime, and fault sequence in the elliptical dome. Our models of dome formation simulated a range of regional strain configurations relative to dome shape and orientation. Fault patterns interpreted from 3D seismic data correlate well with fault patterns developed in models that simulate a regional extension. Our models indicate that evolving faults and fault systems exist simultaneously at a range of sizes regardless of regional strain orientations and magnitude. Moreover, the number of small-displacement faults, those typically undetectable by seismic methods, exceeds the number of faults detected by the resolution of the seismic data. Results indicate that the offshore dome formed in an extensional regional deformation field dominated by NE-SW extension, oblique to the long axis of the elliptical dome. Fault patterns in the models indicate that doming was concurrent with and possibly preceded by regional extension.

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Estimation of sub-seismic fault populations

In order to characterize frequency distribution of sub-seismic (<10m throw) extensional faults in carbonate rocks we used outcrop maps derived from photo-mosaics or scanlines of well-exposed normal fault systems in Cretaceous strata from 4 locations in Texas. We calculated average extension direction, extension-parallel heave and fault frequency, and total fault-expressed extension. Three key observations from mapping are: (1) fault frequency increases with total extension, (2) small-displacement faults are more numerous in rocks with higher total extension, and (3) a few large faults accomplish most of the total extension. Scanlines from a 3D seismic reflection survey of faults in a carbonate reservoir exhibit lower fault frequency, and the proportion of small-displacement faults is very low compared with outcrop data. This data gap arises because small-displacement faults are not resolved by seismic images. One approach to correcting this data gap is to synthetically add faults of appropriate displacement into the seismic dataset. The basis for this correction is that total extension determines fault frequency, and the largest observed faults provide a good representation of the total strain. The difference between total extension and that accommodated by observed faults is the extension deficit. Using estimates of the extension deficit, the total number of faults that should be present can be calculated. The size distribution of all faults in the population can be determined using the total extension, the total number of faults, and an empirical power-law relationship between fault displacement and frequency.

Working for a not-for-profit research and development organization in the earth sciences

H.L. McKague, Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, 6220 Culebra Road, San Antonio, Texas 78238

Southwest Research Institute (SwRI) is an independent not-for-profit applied engineering and physical sciences research and development organization. This means that SwRI owes no allegiance to organizations other than its clients. As a not-for-profit organization, SwRI reinvests its net income into the organization to improve, strengthen, and expand facilities and to support internal research and development projects. Located in San Antonio, Texas, on 1200 acres, SwRI employs nearly 2800 staff and occupies nearly 2,000,000 square feet of office space. Its business is about equally divided between commercial and government clients, most of whom have specific scientific and technical problems that need to be solved in a timely, cost-effective manner. Governmental clients include local, state, and federal agencies and foreign governments. Commercial clients include local, national, and international businesses. Earth science disciplines at SwRI include geology, geophysics, hydrology, geochemistry, rock mechanics, mining engineering, and natural hazard assessment. Our overall approach is to systematically examine client problems and develop solutions that may include field work, laboratory work, numerical modeling, or some combination of these approaches. This method of problem solving places a strong emphasis on interdisciplinary teamwork. The work environment at SwRI strikes a balance among the freedom to attack technically important problems, consistent support to professional development, and a strong commitment to meeting client's deadlines and goals. Real problems with real consequences are routinely solved on a tight schedule. The diversity of clients gives exposure to an extraordinarily wide range of problems. Successful employees have sound technical backgrounds, are flexible in accommodating varying clients needs, bring creativity and energy to problem solving and applications of technologies, can work on multiple tasks in parallel, and can communicate clearly with clients and other team members. Professional development is supported through encouragement of continuing education, as well as publication and presentation of professional work. An overview of the earth science staff and work at SwRI can be found at http://www.swri.edu/4org/d20/d20home.htm