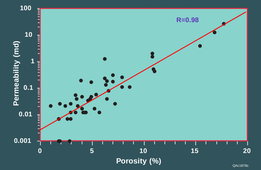
# PETROPHYSICS

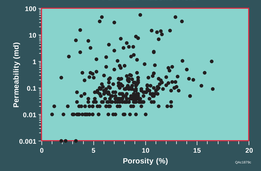
## POROSITY AND PERMEABILITY

### GRAYBURG PETROPHYSICS
### SILTSTONE-SANDSTONE FACIES
### Fuhrman-Mascho Field



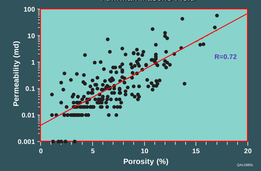

7. Grayburg porosity is largely confined to inner platform, cycle base siltstones and sandstones. Because of their intercrystalline pore space, these rocks display a good porosity/permeability relationship and, locally, very high permeabilities.

### UPPER SAN ANDRES PETROPHYSICS
### TIDAL-FLAT FACIES
### Fuhrman-Mascho Field




8. Upper San Andres (USA) porosity is most common in tidal-flat facies. But because the pore space in these rocks is mostly composed of separate vugs, they generally have extremely low permeability and high water saturation.

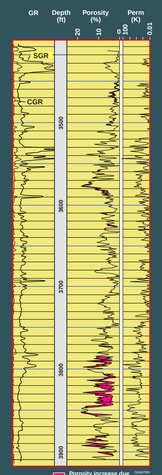
### LOWER SAN ANDRES PETROPHYSICS
### RECRYSTALLIZED FUSULINID FACIES
### Fuhrman-Mascho Field




9. Lower San Andres (LSA) porosity comprises moldic and intercrystalline pores and is restricted to the uppermost 70 ft of the sequence (HFS 4). Generally there is a good relationship between porosity and permeability.

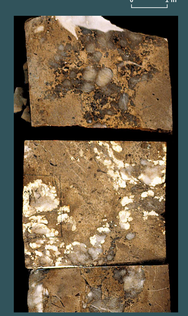
## CAVEATS TO RESERVOIR EXPLORATION

An important complication to the interpretation of all San Andres and Grayburg carbonate reservoir successions in the Permian basin is the presence of sulfate. Sulfate is ubiquitous and locally takes the form of gypsum as well as anhydrite.

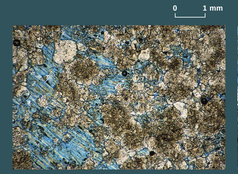


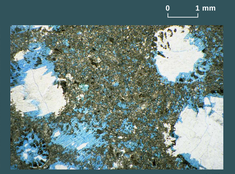

Porosity increase due to core analysis

10. Standard core analysis techniques result in dehydration of gypsum and produce erroneous porosity and permeability reading. Comparison of petrophysical measurements made from low temperature treatment of cores versus the conventional high temperature techniques shows the magnitude or analysis errors.




11. The analysis-induced alteration of gypsum is apparent from these adjacent core pieces, one which was cleaned and analyzed and the others which were not. The white rinds around the anhydrite nodules are dehydrated gypsum.



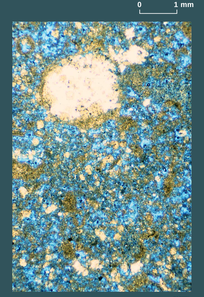




12. Altered gypsum-filling interparticle pore space in ooid/peloid grain-dominated packstone and fusulinid wackestone of the lower San Andres Formation at Fuhrman-Mascho field. Note that the blue color is the result of blue-dyed epoxy injected into intracrystalline pores within the altered gypsum. The abundant gypsum in the San Andres at Fuhrman-Mascho means special precautions must be taken for accurate petrophysical measurements and volumetric calculations.

# EVIDENCE OF UNCONFORMITY-RELATED POROSITY DEVELOPMENT IN THE MID-SAN ANDRES

## FABRIC



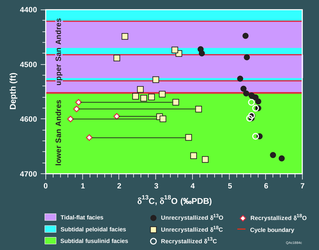



13. Fusulinid facies in the upper part of the Lower San Andres contain abundant vertical, tubular areas of recrystallized dolomite. In many cases, there is strong evidence that vertical tubules are a result of burrowing . Recrystallized zones diminish in abundance downsection although evidence of burrowing does not. Commonly these burrowed vertical zones contain abundant sulfate nodules.

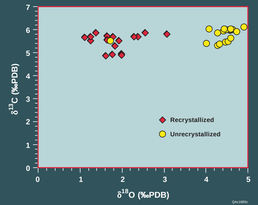
Microscopically, these fabrics commonly display enlarged crystals and, in many cases, leached dolomite rhomb cores.

## CHEMISTRY

### STABLE ISOTOPE TRENDS, SAN ANDRES FORMATION
### Fuhrman-Mascho Field



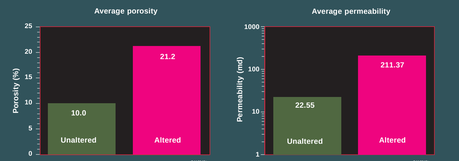

### STABLE ISOTOPE TRENDS, GRAYBURG FORMATION
### South Cowden Field




14. Comparison of isotopes from recrystallized and adjacent unrecrystallized areas in the lower San Andres shows that recrystallized dolomite is markedly depleted in $\delta^{18}O$ (2 to 3 ‰PDB). The absence of similar depletions in the upper San Andres suggests that fluids predated upper San Andres diagenesis or entered the top of the lower San Andres along the unconformity. Similar patterns of isotopic depletion have been documented in several other San Andres and Grayburg successions, such as this example from the South Cowden Grayburg field.

## PETROPHYSICS

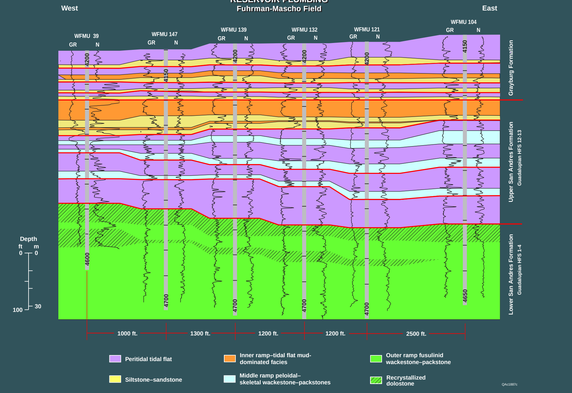
### POROSITY AND PERMEABILITY OF ALTERED DOLOMITE ZONES
### South Cowden Grayburg Reservoir




15. Both porosity and permeability are markedly higher in recrystallized zones than in surrounding unrecrystallized matrix. Low permeability is normally characteristic of fusulinid-bearing facies because of the dominance of separate vug (fossil-moldic) pores. The recrystallization of these rocks along burrows has altered the rock fabric to produce significant intercrystalline porosity and, accordingly, higher permeabilities. However, although permeability can be quite high in these zones their tubular nature and probable poor lateral interconnections suggest that effective permeability may be much lower.

## GEOMETRY

### RESERVOIR PLUMBING
### Fuhrman-Mascho Field




16. The development of burrowed zones, recrystallized dolomite, and higher porosity and permeability is a direct function of proximity to the unconformity surface. This suggests that all of these features owe their origin to diagenetic fluids entering the lower San Andres along the unconformity surface.

QAc 7/15