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"Tight" Abo Gas Sands, East-Central New Mexico

Red-bed sandstones of the Abo Formation (Lower Permian) currently produce natural gas from the Pecos Slope Abo field in northern Chaves County, New Mexico. The Pecos Slope Abo field is on the northwest shelf of the Permian basin. Production currently comes from an approximately 700 mi^2 (1,813 km^2) area. The Abo has been designated a "tight gas sand," thus Abo gas can be sold for as much as $5.41 per mcf, $2.60 more than the regulated ceiling price of gas produced from formations not designated as tight. The tight-sand designation greatly stimulated drilling and over 250 wells have been drilled since field discovery in 1977. Because of low permeability, wells must be artificially fractured to obtain economic production. Initial production rises from a few tens of MCFGD before fracturing to an average of about 2,200 MCFGD after fracturing.

The Abo red beds are subdivided vertically into three lithologic intervals on the northwest shelf of the Permian basin: a lower "granite wash" interval, a middle mudstone interval, and an upper interval of interbedded sandstone and mudstone.

The lower "granite wash" interval is more than 800 ft (248 m) thick in some places and is composed of interbedded coarse-grained arkosic sandstones and arkosic conglomerates. It rings Abo-age uplifts of granitic Precambrian basement and intertongues shelfward with marine limestones of the Hueco Formation.

The middle interval is about 100 ft (30 m) thick and conformably overlies the lower interval and the Hueco limestones. It is composed of calcareous, sparsely fossiliferous, argillaceous mudstone and minor fine-grained sandstone. It is a marine shelf deposit.

The upper interval is about 600 ft (183 m) thick and is composed of interbedded mudstones and lenticular sandstones. It conformably overlies the middle interval and is disconformably overlain by the dolostones, anhydrites, and fine-grained sandstones of the Yeso Formation. The upper interval intertongues southward with dolostones of the shelf-margin Abo reef facies. Sandstone lenses are generally 10 to 20 ft (3 to 61 m) thick. Sandstones are very fine-grained, arkosic, and hematitic. The upper interval was deposited as a fluvial-deltaic system which prograded south over the marine mudstones of the middle interval.

Gas is produced from sandstones in the upper interval. Primary porosity has been reduced by compaction to values near zero and the average in-situ matrix permeability of Abo sandstones is only 0.0067 md. Such small amounts of matrix porosity and permeability do not contribute greatly to production. The Abo wells tap a gas-filled natural fracture system. Mudstones seal the fractured sandstone reservoirs. Because fluvial-deltaic deposits extend almost 100 mi (161 km) north of present production, the area underlain by potential, fractured, Abo sandstone reservoirs is at least five times greater than the area which is currently productive.

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Preservation of Trace Fossils in Flint in European Chalk

It has long been known that many flint concretions in the European Upper Cretaceous chalk represent burrows of organisms. In particular, the ichnogenus *Thalassinoides* is readily recognizable in branched networks of flint developed more or less parallel to bedding, while other ichnogenera such as *Zoophycos* and *Chondrites* are commonly preserved on the surfaces of such nodules. However, until recently, the value of this qualitative information has been restricted because the trace fossils are more or less invisible beyond the boundaries of the flint. It has not been clear, therefore, to what extent trace fossils preserved in flint zones are present at flintless zones. For example, in flint-bearing sequences, was the formation of beds of "thalassinoid" flints restricted in any degree to horizons especially bioturbated with *Thalassinoides suevicus*? Conversely, is heavy *Thalassinoides suevicus* bioturbation restricted to zones bearing thalassinoid flints?

The development of a technique involving painting oil onto polished surfaces of chalk is now greatly refining our knowledge of the distribution of trace fossils in pure white chalk, where they are otherwise barely visible, and we are now in a better position to evaluate the ichnological evidence provided by flint preservation. Patterns of distribution are emerging. It is becoming clear, for example, that the many different morphologies of thalassinoid flints are characteristically associated with different sedimentological settings. Thus, fully developed, sizable thalassinoid flint boxworks occur in autochthonous chalks containing correspondingly large, idiomorphic *T. suevicus* boxworks; straggly, malformed thalassinoid or "finger" flints have been found in slightly allochthonous chalks where the burrows have been dislocated or streaked out; and in unbioturbated allochthonous chalk, thalassinoid concretions are absent and flint may occur as rounded or irregular forms incorporating siliceous sponge body fossils. Such flint fabrics are easily recognizable and visible in the field and are showing themselves to be a useful aid in detailed sedimentological interpretation of chalk sequences.

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Structural Interpretation from Horizontal Seismic Sections

The interpreter of a 3D survey must use a data volume. Horizontal slices through a data volume, called Seiscrop™ sections, have unique properties and structural interpretation from them is fast, convenient, and effective. An event on a Seiscrop section displays local strike, a property which permits direct contouring of a structural surface without any timing and posting. The width of an event on a Seiscrop section is a composition of the frequency of the data and the structural dip. Event terminations indicate faults or other discontinuities when they are transverse to structural strike. Faults parallel to structural strike are much less evident on a single Seiscrop section but become apparent with the relative movement of events from section to section. In practical mapping, we normally contour one fault block before proceeding to the next with the correlation between them being established from the vertical sections. With dual polarity variable area displays, the interpreter can perceive five amplitude levels and normally picks the edge of a trough. With color amplitude Seiscrop sections, it is possible to pick on the crest of any event. With color phase sections the interpreter can pick at any arbitrary but consistent point on the seismic waveform. Subtle structural features are commonly revealed on horizontal sections which may never have been noticed if working from vertical sections alone.

The figure shows a Seiscrop section at 1,656 msec from a data volume recorded in a Tertiary clastic sequence offshore Trinidad. The section shows all the events at this level over the 32 mi^2 (82 km^2) area. Three faults are evident running the full length of the prospect.