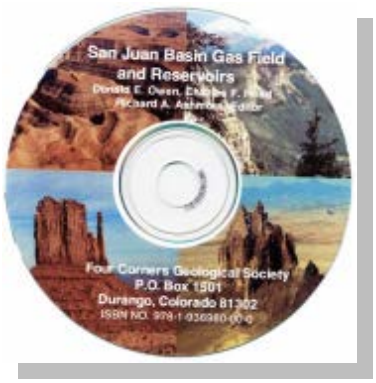

San Juan Basin gas field and reservoirs, by Donald E. Owen & Charles F. Head, Edited by Richard A. Ashmore, 2011.
Four Corners Geological Society, Durango, CO, USA
(order through: www.fourcornersgeologicalsciety.org/store/index.asp).
PDF file on CD-ROM, 113 pp. Price USD 20.00. ISBN 978-1-936980-00-0.

The development of sedimentology has been highly beneficial for the exploration of hydrocarbons. Nowadays, there is much geological return on investment: oil exploration results in an incredible and ever growing wealth of both field and drill-core data that increase the insight into the sedimentological developments of the rocks under study. Few sedimentologists get the opportunity, however, to see for themselves, the sedimentology of a gas field outside their own working area. This is possible now, thanks to a field-trip guide that was prepared for the 59th Annual Meeting (2010) of the Rocky Mountain Section of the American Association of Petroleum Geologists. This field guide has recently been published in the form of a CD-ROM making it possible for all those who want to take this field trip on their own.

The leaders of the field trip, Donald E. Owen (Department of Earth and Space Science, Lamar University) and Charles F. Head (ConocoPhilips) are also the authors of this CD-ROM. Interestingly, the CD-ROM has an ISBN (International Standard Book Number), but this may be due to the fact that the work was initially published on paper; I could, however, not find this ISBN on internet.

The field trip is a 350-km traverse, mainly just east of the Four Corners area (the area around the only point in the USA where four states - Utah, Colorado, Arizona and New Mexico - touch each other), through the surrounding high desert and southern Rocky Mountains, but mainly within the San Juan Basin. This basin is also well known among paleontologists because of the controversy concerning the age - Cretaceous or Paleogene - of the youngest dinosaur remnants. The main topic is, however, as the title indicates, the geology (and particularly the sedimentology) of the gas and oil fields. Cretaceous and Tertiary reservoir outcrops, as well as landforms, provide the basic data regarding the stratigraphy, history of exploration and development, and the hydrocarbon system of the basin. Apart from that, interesting landmarks also form part of the trip. The famous Ship Rock (a neck) is such a feature that is known worldwide; another one is Mesa Verde (a table mountain), where prehistoric Indian dwellings, especially the famous Anasazi, remind one of America's past.

The excursion described in this field guide shows how closely hydrocarbon exploration and sedimentology are interwoven. Perfect exposures invite any excursion participant to study the sedimentology and to take samples. There are, however - how unfortunate from a geologists' point of view, but how fortunate from the point of view of caring for America's heritage! - some restrictions: in Navajo Nation the disturbance or collection of geological, paleontological or archeological samples or remains is not permitted. Geologists should first apply for - and receive - a permit from the Navajo Nation Minerals Department (P.O. Box 1910, Window Rock, Arizona 86515). But if such a permit is granted, there is much to see. I mention here only some of the most interesting points described in the guide, as examples.

At Carbon Junction (Colorado), the Pictured Cliffs sandstones and the Fruitland Formation are exposed (Carbon Junction is named for a thick coal seam). The road section consists of, from bottom to top, the Lewis marine mudstones and siltstones, the Picture Cliffs shoreface sandstones, and the Fruitland swamp/marsh to fluvial floodplain sediments, including coals. These three formations were deposited in the Cretaceous Western Interior Seaway in a depositional system that included coastal plain, shoreface, and offshore environments, which can well be recognized on the basis of their sedimentological characteristics.

The Lewis Shale (approx. 400 m thick here) consists of tight sandstones, siltstones and shales, which are productive gas reservoirs where naturally fractured. The Picture Cliffs Fm. is a tight sandstone reservoir with 4-20% porosity. The pores are generally very small in this fine-grained sandstone, and many pores are at least partially occluded by pore-filling cements and clays. Instead of producing gas from pores, as in most sandstones, the coal produces gas from fractures known as 'cleats'. Adsorption holds the gas in the coal.

At Cedar Hill (New Mexico), the Cedar Hill Fruitland Coal Pool was discovered in 1977. The Fruitland Formation has since become the world's most prolific coal-bed methane play, and it has produced more gas than any other rock unit in the San Juan Basin. Nearly all the basin's gas comes from Cretaceous reservoirs, which include tight sandstones, coals, and fractured siltstones/shales. The entire section is gas-saturated in a large stratigraphic traps with water updip of gas.

In the center of the Hogback oil field (New Mexico), rocks cropping out in the cliffs are the Tocito Sandstone Lentil of the Mancos Shale, deposited primarily as sub-tidal sandbars. This outcrop is situated on the Hogback Oil Field anticline. Many of the typical facies of the Tocito occur at this outcrop. The base of the channel-fill sandstone is interpreted as merging with the sub-Tocito unconformity along the crest of the anticline. The basal Tocito unconformity is interpreted to be at the change in texture and color observed near the base of this outcrop. Tocito reservoirs have produced the majority of the oil recovered from the San Juan Basin and contribute significant oil and gas quantities in many other fractured pools. The Tocito Sandstone has some of the best matrix porosity and permeability in the basin, and it exhibits distinctive log inflections in high-quality, hydrocarbon-saturated reservoirs. The prolific nature of the Tocito Sandstone is directly related to its reservoir stratigraphy, trapping mechanisms, and proximity to oil-prone source rocks. Most of the Tocito reservoirs in the San Juan Basin are now fully developed and pressure-depleted. The depositional (and erosional) setting of the Tocito Sandstone here has been interpreted in different ways: as a strike-valley sandstone, as a longshore bar complex, and as a transgressive sandstone. It is also still under discussion whether the basal Tocito unconformity is subaerial or submarine, what was the role of eustacy versus tectonism, and what were the precise depositional systems.

A stop at Four Corners Platform (NM) shows the Dakota Sandstone near the town of Shiprock. This excellent exposure of the upper part of this formation displays fluvial sandstones, including a spectacular isolated channel sandstone visible in three dimensions, and paludal shales with coal overlain by an onlapping set of thin marine shale and sandstone.

The above outcrop and all other exposures are clearly described in the guide book, and also shown on a map which shows the itinerary. In addition, the guide contains a wealth of explanations in the form of full-color illustrations. Several articles which have been published

about specific subjects are included as well. This all makes this field guide a most practical and informative piece of work that allows any geologist to make this excursion on his own.

In past decades, I was fortunate to be able to travel through this area numerous times, and I was surprised time and again by the beauty of the landscape, the variation in geology and the numerous ideal exposures. But how much more I could have enjoyed these trips and how much more I would have learned about the relationship between sedimentology and hydrocarbon exploration if I had had this field guide with me! The low price of the CD-ROM (at least in comparison with a similar work in print) should seduce many geologists. And they need not go on their own but rather bring their partner, too, particularly if he/she is not interested in geology but loves the scenery of the Southwest US. Taking this trip will be most enjoyable for both geologists and tourists.

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