INTRODUCTION

The Hunton Group represents a prolific oil and gas producing horizon in both the Midcontinent and the Midland Basin. Equivalent strata in the Black Warrior Basin and other interior basins also show potential for production. Most of the Hunton accumulations are structural/stratigraphic traps, often produced by truncation of porous carbonate across structural noses. Some of the greatest potential for Hunton production is now found in the deepest parts of the Anadarko Basin; some of the deepest gas fields in the world are located in the Hunton Group at depths below 20,000 ft along the Oklahoma/Texas border.

From 1982 to 1989, the Hunton Group was studied by employees and consultants of Masera Corp. as part of a commercial project. The project area included the Anadarko Basin, central and southern Oklahoma, and the Arkoma Basin (Fig. 1). More than 10,000 wells were correlated and evaluated for reservoir potential. Regional and detailed cross sections were built and used to construct detailed maps that show thickness and net porosity of individual zones within the Hunton. Although most of the results of this project are still proprietary, some of the basic findings are discussed in this paper.

REGIONAL SETTING

The Silurian-Devonian was a time of widespread marine-carbonate deposition. Marine waters covered the Trans-Continental arch and most of the Canadian shield. In fact, the transgression responsible for this expansive sea was fully as extensive as that of the Ordovician. Considering the great thickness of Cambrian-Ordovician carbonates, the Silurian-Devonian strata were deposited as a relatively thin veneer of limestones and dolomites, with locally significant deposits of sandstone and shale.

In the Midcontinent, the Latest Ordovician-Silurian-Early Devonian is represented by the Hunton Group, which was deposited primarily as subtidal/intertidal facies in a ramp-type environment. Outside the Midcontinent, extensive reefs are present in equivalent strata along the cratonic edges in Nevada, Canada, Franklin trough of Baffin Island, and Greenland. Off-shelf, dark graptolitic shales are typical basinal sediments.

Silurian strata are more extensive than the Devonian and are preserved in diatremes in northern Colorado and southeastern Wyoming on the crest of the Trans-Continental arch (Fig. 2; Wilson, 1975). Silurian and Lower Devonian carbonates are also found in karstic deposits within underlying Ordovician strata in the Llano uplift.

STRATIGRAPHY

The Hunton Group is a readily recognizable distinctive unit because it is stratigraphically sandwiched between the Woodford Shale, above, and the Sylvan Shale, below (Fig. 3). The Hunton is composed of sequences of dolomite, limestone, and calcareous shale. Based primarily on outcrop surveys, the Hunton is divided into a number of formations. The Chimneyhill Subgroup, at the base, is comprised of the Ordovician Keel Formation and the overlying Silurian Cochrane and Clarita Formations (Amsden, 1961, 1975, 1980). The Chimneyhill is overlain successively by the Silurian Henryhouse and the Devonian Haragan and Bois d'Arc Formations (Fig. 4). In central and southern Oklahoma, the Bois d'Arc is overlain by the Frisco Formation, and in the Arkoma basin the uppermost Hunton is composed of the Sallisaw Formation (Penters Chert). Some workers do not include the Sallisaw Formation within the Hunton Group.

The overlying Woodford Shale and equivalent strata are part of an extensive sequence of hydrocarbon source beds that provided oil and gas for many of the Paleozoic petroleum reservoirs. The Woodford underlies most of Oklahoma, ranging in thickness from a feather edge in northern Oklahoma to >700 ft in southern Oklahoma. It contains conodont fauna of Late Devonian to Early Mississippian age.

The Woodford is easily distinguished on outcrop by its dark-gray to black color and its cherty composition, and in the subsurface it is an excellent "marker bed" because of its distinctive "high" gamma-ray response (Fig. 3).

The underlying Sylvan Shale is typically a greenish-gray to greenish-brown marine shale. On average the Sylvan is <50 ft thick, although it attains a thickness of >300 ft in the Arbuckle Mountains.

PETROGRAPHY

More than 100 cores from Texas, Oklahoma, and Arkansas were described and evaluated during the course of this study. Recognition of lithofacies in these cores is based on texture, sedimentary structures, constituents, and geometry.

Figure 1. Index map showing area of the Hunton Group study.

Figure 2. Map showing distribution and thickness (in feet) of Silurian strata in North American.
Dant brachiopods (such as the portions of the Hunton contain abun-
dant skeletal fragments and lime mud
material (dominantly crinoids)
ments consist mostly of pelmatozoan
mon in high energy facies. Skeletal frag-
ments supported textures, whereas the
medium-bedded strata are present on
associated with fenestral fabric. Thin- to
oolitic grainstones and packstones. Algal
facies are described below:
Upper subtidal to lower intertidal.—This
facies is typically a crinoidal wackestone. Brachiopods are also present; trilobites and bryozoans may be present, but are rare. Burrowing is the most common sedimentary feature; it probably enhances permeability of this facies for later diagenesis, which forms a
reservoir-quality lithology. Lagomphes
Lagomphes may form in this
facies. The sediments that are
deposited typically are peloidal wacke-
stones.
Subtidal.—This facies can also be subdivi-
sed into upper and lower (open-
mained systems, in response to wave
tidal and subtidal facies, can form
upper and lower parts (Fig. 7). Adjacent
environments, such as the transitional area between
rather subdivided into upper and lower
areas such as the Pensacola Gulf have similar
gemistry. It is thought that the local
slope associated with the shoaling areas
on the ramp were generally steeper than
the very gentle slope of the sea floor.

**DEPOSITIONAL MODEL**
Based on the petrographic examina-
tion and evaluation of outcrops, cores,
and samples, several distinct environ-
ments and related lithofacies can be
identified. The basic depositional envi-
ronments are supratidal, which occurred
above high tide; intertidal, which
occurred below high tide and above low
tide; and subtidal, which occurred below
low tide. These environments can be fur-
ther subdivided into upper and lower
facies are described below:

**Upper intertidal to supratidal.—A
luminated mudstone predominates in
this environment. Peloidal fabrics are
common and there is a paucity of fossils
and burrowing. Algal carbonates and
replacement epivores, such as silica nod-
ules with relic anhydrite crystals, are pre-
sent in this facies (Chowns and Elkins,
1974; Beardall, 1983).

**Cyclicity**
The above facies occur in shallowing-
upward cycles or parasequences. A com-
plete sequence is shown in Figure 9;
however, it is important to recognize
that complete sequences are not com-
nonly observed, due to progradation
and deposition of terrigenous debris.
As previously discussed, the Hunton is
comprised of a series of progradational,
aggradational sequences that built geo-
metrically seaward on a ramp. The com-
position of each parasequence is depen-
dent on its position on the ramp.
For example, a sequence from the
Henryhouse Formation on the outer
ramp (e.g., southern Oklahoma out-
crops) is relatively thin (<95 ft) and is

**DEPOSITIONAL ENVIRONMENT**
Based on core and outcrop descrip-
tions, the Hunton was deposited on a
broad ramp in a shallow epicontinental
sea (Fig. 6). Overall slope is relatively thin
(<25 ft) and is
Figure 4. Correlation chart of the Woodford Group modified from Rinkcker, 1972, 1973, 1974.
typically composed of open marine calcareous shales and mudstones that shallow upward into subtidal mudstones and wackestones (Fig. 10). Farther up the ramp (e.g., Anadarko basin and shelf), equivalent Henryhouse strata are represented by thicker sequences (>50 ft) composed, from bottom to top, of the following: (a) lower subtidal mudstones and wackestones, (b) shallow subtidal wackestones, packstones, and grainstones, and (c) lower intertidal wackestones and packstones. On the upper ramp (e.g., northwest Oklahoma shelf), the sequences are usually composed of intertidal to supratidal deposits that are sometimes truncated by local intra-Henryhouse unconformities.

SEQUENCE STRATIGRAPHIC MODEL

One of the keys in developing an understanding of a potential pay is to integrate all data from cores, outcrops, samples, logs, etc., into a comprehensive model that can be used to evaluate reservoir characteristics for exploration and exploitation purposes. It is particularly important to understand facies vs. log response, even if it's only qualitatively, to provide a framework for detailed correlation and discovery.

FACIES VS. LOG RESPONSE

In the Chimneyhill through Bois de Bonneterre (Fig. 5), depositional textures are recognizable, and their classification can be used to infer the depositional environment. The classification chart (Dunham, 1962) uses the presence or absence of mud, grain-supported vs. mud-supported, and the grain size to distinguish between different facies (Fig. 6). This helps in understanding the depositional setting and potential reservoir characteristics.

<table>
<thead>
<tr>
<th>Depositional Texture recognizable</th>
<th>Depositional texture not recognizable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original components not bound together during deposition</td>
<td>Crystalline carbonate</td>
</tr>
<tr>
<td>Contains mud (particles of clay and fine silt size)</td>
<td>(Subdivide according to classifications designed to bear on physical texture or diagenesis.)</td>
</tr>
<tr>
<td>Mud-supported</td>
<td>Grain-supported</td>
</tr>
<tr>
<td>Less than 10% grains</td>
<td>More than 10% grains</td>
</tr>
<tr>
<td>Mudstone</td>
<td>Wackstone</td>
</tr>
</tbody>
</table>

Figure 5: Dunham's classification chart (Dunham, 1962).

Figure 6. Depositional setting during Hunton time in Midcontinent.
Figure 7. Depositional model for Chimneyhill through Bois d'Arc strata.

Figure 8. Depositional model for Frisco Formation.

Figure 9. Idealized sequence showing relationship of lithofacies to depositional environments.
d’Arc section, the most consistent factor which controls log response is shaliness. Fine clastics typically occur in the lower energy environments, such as the open marine and lower intertidal settings. Fine clastics are also found in the upper intertidal to supratidal environments, due to windblown deposition, and they may be winnowed by currents into the low-energy subtidal facies.

A typical sequence or parasequence has a low-energy, high-energy, and low-energy configuration from base to top. The effect is that the upper subtidal to lower intertidal settings have the cleanest (lowest) gamma-ray response and the highest resistivity; the open marine to lower subtidal settings have the poorest (highest) gamma-ray response and the lowest resistivity; and the upper intertidal to supratidal responses are in between, and can be quite “shaly” in areas where there is a concentration of windblown clastics (Fig. 11). Of course, there are many variations and exceptions to those observations; this is especially true in areas of high porosity and high water saturations, where the gamma-ray log will show “clean,” but the resistivity will be low.

UNCONFORMITIES

The pre-Woodford unconformity is the hiatus most commonly associated with the Hunton Group. There are also several intra-Hunton unconformities, such as those found at the Silurian-Devonian contact and the base of the Frisco. This later unconformity is the most important because it represents the period of maximum erosion and truncation of the Hunton, even though the time gap is only 1-2 million years. The amount of erosion is substantiated by the stratigraphic relationship of the Frisco to the underlying units (i.e., Frisco can be found resting unconformably on Chimneyhill to Bois d’Arc strata; Fig. 12).

CORRELATION

An extensive network of cross sections was built that included strike and dip sections at a density of at least one per township. The area covered by these cross sections includes the Anadarko basin in Texas and Oklahoma, the Arkoma basin in Oklahoma and Arkansas, and central and southern Oklahoma. Although Hunton outcrop nomenclature has been used by others extensively on the surface, with some accuracy, in the subsurface the use of these names has been extensively misapplied and has led to great confusion in external correlations of the Hunton Group. For example, in central Oklahoma and the Anadarko basin, the uppermost porous unit of the Hunton is often named, and correlated with the Bois d’Arc; in fact, however, the Bois d’Arc has been truncated over most of this area, and the uppermost porous unit is usually Henryhouse or Frisco.

Evaluation of these cross sections and integration of core and outcrop data first revealed that there was not a typical Hunton section for correlation purposes; in fact, at least three type logs are required to understand the stratigraphic relationships of the intra-Hunton sequences. Figure 12 shows the correlations and sequence relationships from west to east among the type sections for the Anadarko basin, southern Oklahoma, and the Arkoma basin.

POROSITY DEVELOPMENT

Significant porosity formation in the Hunton usually occurs in oolitic, dolomitized grainstones (Keel and Henryhouse), and dolomitized, burrowed wacke/packstones (Cochrane, Henryhouse, and Haragan/Bois d’Arc). These units are typically subjected to at least three stages of dolomitization and multiple stages of dissolution in the form of karstification or connate fluids (Manni, 1985) The relationship of dolomitization and facies is shown in Fig. 14.

Porosity development in the Frisco is different than in most other parts of the Hunton; most porosity in the Hunton is related to dolomitization, whereas the Frisco is rarely dolomitized. It typically has inter- and intraparticle porosity combined with moldic to vuggy porosity.

The Penters is unusual in that it has been subjected to intense karstification, typically associated with porosity occlusion; however, the high percentage of chert combined with dolomite develops an extensive fracture system that can drain hydrocarbons from the intercrystalline porosity in the dolomite.

TRAP AND GEOMETRY

Most of the Hunton fields would be classified as structural/stratigraphic traps, with emphasis on stratigraphic. The most common type of reservoir configuration in the Hunton is where porous facies are truncated by either the pre-Woodford unconformity and/or intra-Hunton unconformities along a structural nose. This is particularly true of most of the Henryhouse section in the Anadarko basin, which develops reservoirs wherein the traps are formed by truncation (by unconformity) and both the seal and the source rock are the Woodford Shale (Fig. 15).

Another common reservoir configuration in the Hunton is trapping by permeability barriers caused by facies...
changes or karst profiles along structural noses or faults (Fig. 15).

In the Arkoma Basin, fractured reservoirs and Hunton fields are more commonly related to structural configuration (e.g., Bonanza Field).

CONCLUSIONS

The Hunton Group is a shallow-marine carbonate composed of limestones, dolomites, and calcareous shales that prograded and aggraded onto a ramp. These carbonates are cyclic and can be divided into sequences within formational boundaries that are recognizable in outcrops, cores, and logs. These sequences commonly are separated by disconformities or unconformities and can be correlated regionally. Furthermore, reservoir development in the Hunton Group is facies dependent and reservoir-producing lithofacies can be correlated and mapped (Figs. 16, 17).

Use of core, outcrop, and log relationships, integrated with a comprehensive sequence-stratigraphy model, can greatly enhance success for exploration programs or field development.

SELECTED REFERENCES


Beardall, G. B., 1983, Depositional environment, diagenesis and dolomitization of the Henryhouse Formation, in the western Anadarko basin and


Wilson, J. L., 1975, Carbonate facies in geologic history: SpringerVerlag, New York.

Figure 11. Log showing typical response of SP, gamma-ray, and resistivity curves to depositional environments.

Figure 12. Cross section showing the correlation of type logs for the Anadarko basin, Arbuckle Mountains (southern Oklahoma), and Arkoma basin.
Figure 13. Generalized diagenetic sequence of Hunton dolomites (above) and Hunton limestones (below).
Figure 14. Diagram showing the relationship of dolomitization to depositional facies.

Figure 15. Cross section showing two types of trapping mechanisms in the Hunton: (a) truncation trap (upper porous carbonate) and (b) permeability-barrier trap (lower porous carbonate).
Figure 16. (at left) Isopach map of Frisco limestone at West Edmond field (smaller squares are 1 sq mi). Cross section C-C’ shown in Figure 17.

Figure 17. (below) North-south stratigraphic cross section C-C’ showing the relationship of the Frisco reservoir and underlying oolitic Henryhouse reservoir in the West Edmond field (see Fig. 16 for location.)