THE ALBERTA ENERGY AND UTILITIES BOARD

IN THE MATTER OF Proceeding No. 1457147
to the Alberta Energy and Utilities Board.

BEARSPAW PETROLEUM LTD.;
DEVON CANADA CORPORATION;
ENCANA CORPORATION;
FAIRBORNE ENERGY LTD.;
and CARBON DEVELOPMENT PARTNERSHIP
(successor in interest to Prairie Mines and Royalty Ltd., formerly known as Luscar Ltd.)

CLIVE, EWING LAKE, STETTLER
AND WIMBORNE FIELDS

ARGUMENT

OF

ENCANA CORPORATION

Code Hunter LLP, Counsel for EnCana Corporation
Christian J. Popowich
Katherine Reiffenstein
850, 440 – 2 Avenue SW
Calgary, Alberta
T2P 5E9
Ph: 403.716.2378
Fax: 403.261.2054

November 30, 2006

TABLE OF CONTENTS

ARGUMENT OF ENCANA CORPORATION

I. Introduction

1. EnCana submits that the CNG applicants have not established that they are entitled to a right to produce CBM from the subject wells, as the ownership of CBM is *bona fide* disputed.

2. The Board has no express power to decide that ownership dispute, and such a power cannot be implied as rationally related or reasonably necessary to its purposes.

3. If the Board has the power to decide the question of legal ownership of CBM, it ought not to exercise it here for reasons of procedural fairness – being want of notice, parties, and a full record.

4. If the Board is to decide the question of legal ownership of CBM, EnCana submits that it is the coal owners' under the specific grants and leases here at issue:

   a. there is no evidence from the material times (early and mid-20th century) that "natural gas" under a lease included CBM;

   b. there is evidence from the material times that CBM was used by coal owners who were responsible for it, and so was included in a reservation as "coal";

   c. CBM is a constituent of coal by the common evidence of the experts.

5. EnCana submits that it is entitled to cancellation of the subject Devon and Bearspaw well licenses, on review and variance of the Board decisions dismissing EnCana's objections and granting approval.

6. Bulletin 2006-19 fosters orderly development as it reflects the legal requirement of entitlement for a license, the withdrawal of which will mean simply that all applications to produce CBM from split title lands need be objected to individually.

7. Reducing DSUs and pooling (with proceeds of disputed production to the Minister) are options available to lessen split title disputes, but are not things EnCana seeks to mandate.

II. CNG producers have but Disputed Proprietary Claims to CBM, and not Ownership or Entitlement to Produce It

8. Each and all of the CNG producers acknowledge that the coal owners claim CBM ownership under the material grants and leases, and deny that the CNG producers are entitled to produce CBM.[1]

9. Unless the claims of the coal owners are ignored or the competing claims adjudicated, a CNG producer cannot in any way be "entitled to the right to produce" the CBM as required by the *Oil and Gas Conservation Act* ("*OGCA*")[2], s.16.

10. As was determined by the Court of Appeal in *Goodwell Petroleum Corp., OGCA* section 16 is contravened "if the person who holds the well license does not possess the right to produce the hydrocarbon authorized by the well license".[3]

11. The same court determined also that entitlement depends on the interpretation of the instrument that grants the rights (whether an agreement, reservation or grant).

12. The CNG producers have no express entitlement to CBM and claim it as "natural gas" under various leases, the establishment of which claims require a legal determination that CBM was not reserved or excepted as "coal" and was granted

---

1 See Devon at 55:18-56:12; Fairborne at 86:1-5; Bearspaw at 114:17-115:8; Quicksilver at 450:8-12, 451:18-25; Apache at 498:5-12; Conoco at 532:19-23; FHOA at 612:7-9

2 07-027-2006-09-15 Tab 12; R.S.A. 2000, c. O-6

3 *Alberta Energy Co. v. Goodwell Petroleum Corp.*, 2003 ABCA 277, para 93; 07-024-2006-09-15 EnCana Submission (Revised Tab 4)

as "natural gas" – as those substances *in situ* and before human intervention were understood in the vernacular.[4]

13. Therefore, absent a legal determination that "coal" did not include CBM and "natural gas" under the material documents did,[5] the CNG producers have but a proprietary claim – which is subject to a competing proprietary claim.

14. To grant an application on either a mere assertion (per Bearspaw) or a *prima facie* entitlement (per Conoco) or on provision of a lease (per Quicksilver) the Board would need to ignore competing ownership claims and the law that section 16 is violated absent ownership.

15. As entitlement is required, where there is an objection the Board must consider and determine "relative ownership" and if there are *bona fide* (real or genuine) competing claims, ones which raise a serious issue to be tried, a license may not be granted.

16. The Board can never as a matter of law be satisfied that the CNG producers have entitlement to CBM in the face of *bona fide* competing proprietary claims to CBM.

III. The Board has No Power to Decide Competing Proprietary Claims of CBM Ownership

17. All governmental action must be supported by a grant of legal authority derived from the Board's enabling legislation.[6]

---

4 *Borys* v. *Canadian Pacific Railway* (1953) 7 W.W.R. (N.S.) 546 (P.C.), paras 32 and 19; see 07-024-2006-09-15 EnCana Submission (Revised Tab 6); *Anderson* v. *Amoco* [2004] 3 S.C.R. 3 at 28, 33-4; 07-024-2006-09-15 EnCana Submission (Revised Tab 7)

5 See: *Anderson* v. *Amoco Canada Oil and Gas*, 1998 ABQB 620 – ownership is a matter of law (para 141) reproduced at Centrica Argument, Tab 1; *Borys* v. *CPR, ibid.* at p 6 – the question is what is included in each substance

6 *Giant Grosmont Petroleums Ltd.* v. *Gulf Canada Resources Ltd.*, 2001 Carswell 1058, 2001 ABCA 174 at para.17 (Alta.C.A.)

18. The Supreme Court of Canada has specifically held that a regulatory tribunal requires an express or implied grant of authority to decide general questions of law,[7] which entitlement/ownership is.

19. The Board has neither an express nor an implicit power to decide the competing proprietary claims of CBM ownership of the coal owners and the CNG producers.

20. While the Board may cancel a license if a licensee on notice does not prove entitlement to the Board's satisfaction,[8] this neither requires the Board to decide competing claims as to ownership nor gives it the power to do so.

A. The Board has no Express Power to Decide Competing Ownership Claims

21. The statutory regime requires either entitlement to the substance to produce (well licenses) or ownership (pooling orders and holdings),[9] but provides no express power to decide ownership contests.

22. Absent an express grant of authority, it is necessary to consider whether the legislator intended to confer upon the regulator the implied jurisdiction to decide questions of law, and it is crucial that the relevant intent be clearly defined.[10]

23. Where a comprehensive legislative scheme confers an adjudicative power on some statutory bodies but not on others, the maxim *expressio unius est exclusio alterius* operates to create the presumption that the exclusion is not the result of oversight.[11]

24. The lack of an express power to decide questions of law under the *OGCA* is in stark contrast to those it has under the *Public Utilities Board Act*, which expressly grants the EUB authority to decide questions of law and the powers of a court:

---

7 *Martin* v. *Nova Scotia (Workers' Compensation Board)* 2003 CarswellNS 360, paras 35-41 (S.C.C.)
8 *Oil & Gas Conservation Act*, s.16(2), *supra* note 2
9 07-024-2006-09-15 EnCana Submission (revised), paras 9-12
10 *Martin* v. *Nova Scotia*, *supra* note 7 at para 35
11 *Tétrault-Gadoury* v. *Canada* [1991] 2 S.C.R. 22 at paras 14-17 (S.C.C.)

> Questions of law and fact
>
> 38 The Board may, as to matters within its, jurisdiction, hear and determine all questions of law or of fact.
>
> Board has powers of Queen's Bench
>
> 39 Except as otherwise provided in this Act, the Board has in regard to the amendment of proceedings, the attendance and examination of witnesses, the production and inspection of documents, the enforcement of its orders, the payment of costs and all other matters necessary or proper for the due exercise of its jurisdiction or otherwise for carrying any of its powers into effect, all the powers, rights, privileges and immunities that are vested in the Court of Queen's Bench,[12]

25. While the EUB enjoys all of the powers, rights and privileges of its two predecessor boards,[13] the legislature has seen fit to grant it an express power to decide questions of law under the *PUBA* but not under the *OGCA*.

B. The Board has no Implied Power to Decide Competing Ownership Claims

26. While it is well established that a statutory body has by implication all powers reasonably necessary to accomplish its mandate,[14] the Board here has no implied power to adjudicate competing proprietary claims of the coal owners and the CNG producers.

27. Where a statute does not confer an express power on the Board, it is necessary to interpret the legislation with a view to isolating its essential purpose.[15]

28. The Supreme Court of Canada in *Atco Gas & Pipelines Ltd.*[16] endorsed the following list of factors in assessing whether an incidental power arises from a particular statute:

---

12 *Public Utilities Board* Act, R.S.A. 2000, c.P-45, ss. 38 and 39
13 *Atco Gas & Pipelines*, 2006 CarswellAlta 139 (S.C.C.) at para 56, see 07-024-2006-09-15 EnCana Submission (Revised), Tab 10; *Alberta Energy and Utility Board Act*, ss.13, 15(1)
14 *Ontario* v. *974649 Ontario Inc.*, [2001] 3 S.C.R. 575, 2001 CarswellOnt. 4251, para 70-71
15 *Giant Grosmont*, *supra* at note 13 at para 18
16 *Atco Gas & Pipelines Ltd.* v. *Alberta Energy and Utilities Board*, *supra* para 73

> The Ontario Energy Board in its decision in *Re Consumers' Gas Co.* (1987), E.B.R.O. 410-II, 411-II, 412-II, at para. 4.73, enumerated the circumstances when the doctrine of jurisdiction by necessary implication may be applied:
>
> 1. when the jurisdiction sought is necessary to accomplish the objects of the legislative scheme and is essential to the Board fulfilling its mandate;
>
> 2. when the enabling act fails to explicitly grant the power to accomplish the legislative objective;
>
> 3. when the mandate of the Board is sufficiently broad to suggest a legislative intention to implicitly confer jurisdiction;
>
> 4. when the jurisdiction sought is not one which the Board has dealt with through use of expressly granted powers, thereby showing an absence of necessity; and
>
> 5. when the legislature did not address its mind to the issue and decide against conferring the power to the Board. (See also Brown, at p.2-16.3.)
>
> 74. In light of the above, it is clear that the doctrine of jurisdiction by necessary implication will be of less help in the case of broadly drawn powers than for narrowly drawn ones. Broadly drawn powers will necessarily be limited to only what is rationally related to the purpose of the regulatory framework. This is explained by Professor Sullivan, at p. 228:
>
> In practice, however, purposive analysis makes the powers conferred on administrative bodies almost infinitely elastic. Narrowly drawn powers can be understood to include 'by necessary implication' all that is needed to enable the official or agency to achieve the purpose for which the power was granted; Conversely, broadly drawn powers are understood to include only what is rationally related to the purpose of the power. In this way the scope of the power expands or contracts as needed, in keeping with the purpose. [Emphasis added.]

29. As the Board's powers are broadly drawn, the doctrine of jurisdiction by necessary implication limits the Board's powers to only what is rationally related to the purpose of the regulatory framework – namely, conservation and

prevention of waste as determined by the Alberta Court of Appeal in *Giant Grosmont*.[17]

> The Energy Statutes have a pervasive and uniting theme of conserving Alberta's energy resources. Under the regime as a whole, the conservation of, *inter alia*, oil, gas and crude bitumen is to be ensured. The Board has been given exclusive jurisdiction to address energy` conservation issues generally, including the prevention of waste and wasteful operations. The Board's powers are, necessarily, very broad; it has been given extensive powers to make orders necessary to protect all energy resources. I agree with the chambers judge that "it is clear from the objects and stated purposes of the legislation that prevention of waste and conservation of resources go to the very root of the Board's purpose and existence".

30. The powers of the Board are not to compel development – which is the CNG producers' only argument for deciding: for them, it is somehow necessary "to provide for the economic, orderly and efficient development in the public interest of the oil and gas resources of Alberta", although inexplicably so.[18]

31. However, "orderly development in the public interest" – not a CNG producer's interest – necessitates quiet title to preclude stranded capital, unnecessary surface disturbance, and perhaps litigation.

32. Development cannot be mandated: and as was the case in EUB Decisions 2000-22 and 2003-023, conservation means leaving the resources in the ground;[19] and forcing development implies the public interest is driven by the plans of operators.[20]

33. The Board has no power to compel development – to force someone to produce resources from their lands – and so an adjudication of competing proprietary claims is not rationally related to the Board's broad powers.

---

17 *Supra* at note 6, para 29
18 Devon Written Argument, para 22
19 Chard-Leismer, EUB Decision No. 2003-023 at 10 and 11
20 EUB Decision 2000-22, Surmont at 11.1.4

34. Even if it were said that the powers of the board were more narrowly drawn, the jurisdiction to decide private proprietary claims is not necessary to accomplish the objects of the legislative scheme and it is not essential to fulfil the Board's mandate.

35. As provided by EUB Directive 56:[21]

> When conducting an audit, the EUB relies upon the representations made by the applicant/licensee and documents submitted by the applicant/licensee. The EUB does not verify legal or beneficial title. The issuance of a license or conducting of an EUB audit is not to be relied upon by the licensee or third parties as a legal determination or confirmation of entitlement.

36. The Board has the power to cancel a license, if after issuance it seeks the licensee to prove entitlement and that is not done to the Board's satisfaction.[22] The Board only needs to decide whether there is entitlement, or simply a claim; the Board does not need to adjudicate competing claims.

37. The legislative scheme is directed at preserving rights.

a. Section 4(d) of the *Oil and Gas Conservation Act* provides that the Act is to "afford each owner the opportunity of obtaining the owner's share of the production of oil or gas from any pool", which requires preservation of the status quo given the absence of adjudicatory functions.

b. Section 16(2) of the *Oil and Gas Conservation Act* permits the Board to cancel a licence if an owner is unable to prove to the Board that it is entitled, but provides nothing in the way of adjudication.

c. In the context of pooling orders, s. 86(1) provides for payment to the Minister pending an order of the Court of Queen's Bench where there is a dispute as to the proceeds of production, with no provision for adjudication.

---

[21] EUB Directive 56, Energy Development Applications and Schedules s.4.1, p.37
[22] *Oil & Gas Conservation Act*, s.16(2), discussed *supra* at note 2

38. Implying a power to decide competing proprietary claims would contradict the Act as ownership is a legal issue ultimately to be decided by the Courts;[23] only the status quo pending such will "afford each owner the opportunity" of obtaining his share of production. And it would make meaningless the requirement of s.86 to pay proceeds of disputed production from pooling to the Minister.

39. As said in *McKenzie* v. *British Columbia (Minister of Public Safety)*[24]

> The decision to grant or withhold a government license or privilege, or the adjudication of a breach of such license or privilege, is a markedly different function from what is required of a tribunal constituted to try, as between citizens, issues arising in relation to a statute governing a realm of private law. ...

40. The power to consider whether to suspend a license because the licensee has not proven to the Board's satisfaction an entitlement to produce the substance is not jurisdiction to decide competing proprietary claims.

41. The entitlement to CBM under the relevant grants and leases – whether it is "coal" or "natural gas" – is a private law matter under the competence of the civil courts.[25]

42. The Board does not determine contractual arrangements and relies on the parties, as noted in correspondence Bearspaw exhibited:[26]

---

23 See *Alberta Energy Corp.* v. *Goodwell Petroleum Corp.*, discussed *supra* at note 3

24 2006 CarswellBC 2262, para 134 (S.C.)

25 See: *Garland* v. *Consumers Gas Co.* 2004 CarswellOnt. 1558 (S.C.C.) at paras 70-71 where a dismissal of a lawsuit in respect of a late payment penalty by the gas company on the basis that it was a "collateral attack" on the Ontario Energy Board was overturned as it was a matter of private law concerning the recovery of money wrongfully paid. *Atco*, paras 58-59 where the Supreme Court specifically rejected the argument that the Board had authority "to interfere with ownership rights" by allocating proceeds of sale of a private utility to public ratepayers, even though the EUB enjoyed "exclusive jurisdiction" over the conservation of natural resources. *Curly Posen and Motion Picture Theatres Association of Canada* v. *Minister of Consumer and Corporate Affairs* [1980] 2 F.C. 259 (F.C.A.) where the Board's argument that it had authority to consider contracts between cinema operators and film distributors was rejected as such a determination involved an adjudication of "questions respecting ownership, as between various parties ...".

26 See Bearspaw Exhibit C02-020-2009-06-29, 10 July 2006 EUB letter.

> Upon review of the documentation, please be advised that the EUB does not get involved in determining the viability of contractual arrangements within the industry, but rather relies on information from those involved in the contracts (i.e. the lessor and the lessee). As such, I would advise Bearspaw to forward a copy of their solicitors June 27, 2006 submission to [redacted]. Thereafter, I would advise both parties to direct their concerns to an authority, who can decide on such contractual matters.

43. And that appears to have been the practice for some time, having regard to the evidence of it recorded in the trial decision of *Anderson* v. *Amoco*.[27]

C. Irrelevant Considerations May Not be Taken into Account

44. Extraneous commercial complaints are not relevant considerations on the issue of whether the Board may decide the entitlement dispute.

45. Assertions that the coal owners would have a development veto or strengthen their commercial position if the Board does not decide entitlement[28] are irrelevant to this matter, as is competitive drainage – aside from any question of their lack of foundation.

46. The test in considering whether the Board ought to exercise its discretion in issuing a license was stated by Lord Denning in *Congreve* v. *Home Office*:[29]

> Undoubtedly those statutory provisions give the Minister a discretion as to the issue and revocation of licenses. But it is a discretion which must be exercised in accordance with the law, taking all relevant considerations into account, omitting irrelevant ones, and not being influenced by any ulterior motives.

47. There is no power express or implicit under the Act which permits consideration of the commercial relations of the parties. The purposes of the Act are to effect

---

[27] *Anderson* v. *Amoco*, *supra* note 5 at para 144
[28] See Quicksilver Argument, para 106; Devon Argument, para 72-6
[29] [1976] Q.B. 629 (C.A.) at 649

conservation of resources and to provide for their orderly and efficient development in the public interest.[30]

48. The Board's express power is conservation of resources, which it can do by shutting them in,[31] and forcing development implies the public interest is driven by the plans of operators.[32]

49. The Board has no power to ignore the law that ownership underlies entitlement, and cannot grant CBM licenses where that has not been established, simply to permit development.

50. There is, in any event, no development veto for the coal owners – as the CNG producers have only disputed claims to CBM, and not undisputed entitlement.

51. There can be no "veto" as the CNG producers have no decided right or entitlement to CBM which is being vetoed. The facts are simply that the CNG producers cannot develop what they have not proven they own.

52. The facts are unlike *Goodwell*, where there was a veto because undisputed ownership rights could not be exercised without another's consent (by precluding undisputed bitumen extraction without permission of the gas owner).[33]

53. The rights in Goodwell overlapped but were not inconsistent; here, the claimed rights are inconsistent, as both the coal owners and the CNG producers cannot own the CBM.

54. It is open to the CNG producers to seek agreement or a declaration of ownership before the courts, but as they have chosen not to do that it is hollow for them to suggest anyone else has some fault.

---

30 OGCA, s.4(a) and (d)
31 See *Alberta Energy Co.* v. *Goodwell Petroleum Corp.*, *supra* note 3 at para 41, note 17
32 *Ibid*, paras 29-32
33 *Ibid*, at paras 80, 82, 84

55. EnCana is in the exact same position. It cannot drill into its coals for CBM unless it has the consent of the CNG producers, and the very fact of this hearing and dispute shows the CNG producers are not prepared to provide that on acceptable terms.

56. And the same measure and balance apply to suggestions that concerns for drainage favour deciding ownership.

57. It is not open to the Board to consider competitive drainage, aside from any question of whether there is such or that anyone is more affected than another.

58. The Board has no power to prevent drilling on the basis that it will drain a pool under adjoining lands nor can the Board force a party to exploit its resources. The law of capture continues and is in no way mitigated by the *OGCA*.

59. The evidence here, in any event, is that there is no drainage: the primary porosity system is relatively impermeable by all accounts.[34] And coal owners, whether those here or others, also face drainage from undrilled lands.

60. In any event, a pooling order providing for drilling and production with payment of the proceeds – after the costs of drilling – to the Minister would protect all in maintaining the status quo.

IV. Even if the Board has the Power to Decide the Competing Proprietary Claims to CBM Ownership, it Ought Not to Exercise It

61. Even if the Board has the power to decide the competing claims of ownership of CBM under the relevant grants and leases, it ought not to – for want of procedural fairness, including notice and disclosure, and parties.

62. It is now well established that as a general common law principle, there is a duty of procedural fairness lying on every public authority making an administrative

---

[34] M.J. Mavor, *Testing for CO_2 Sequestration in Enhanced Methane Production from Coal*, SPE 75683

decision which is not of a legislative nature and which affects the rights, privileges or interests of an individual.[35]

63. The common law duty to proceed fairly requires that the parties affected by the possible outcome of an administrative dispute receive adequate notice of proceedings as well as the nature of the issue to be decided,[36] as does the *Administrative Procedures and Jurisdiction Act*.[37]

64. There was no notice here that the Board was to determine the competing proprietary claims to CBM under the leases and grants at issue. The Notice of Hearing, Part 2 of Proceeding No. 1457147 said:[38]

> ... This Notice is being distributed to advise interested persons that the Board has now undertaken a review of the issue of legal entitlement of coalbed methane being produced or intended to be produced from certain wells on split title freehold lands, more particularly described below.
>
> ...
>
> ... In Part 2, the Board will consider
>
> - the issue of legal entitlement of coalbed methane being produced or intended to be produced from wells that have been licensed to Bearspaw Petroleum Ltd., Devon Canada Corporation, and Fairborne Energy Ltd., as more particularly described below; and
>
> - any outstanding measurement and accounting issues of coalbed methane production in connection with the said wells arising from the cancellation of Part 1 of Proceeding No. 1457147.

65. The Notice does not say that the Board would decide who owns CBM under the many leases and grants at issue here – let alone absolutely for all leases and grants.

---

35 *Potter* v. *Halifax Regional School Board,* [2002] N.S.J. 297 (N.S.C.A.) at para 34; aff'd [2002] S.C.C.A. 306 (S.C.C.)
36 *Supermarché Jean Labrecque Inc.* v. *Quebec* (Tribunal du travail) [1987] 2 S.C.R. 219 at 233-4
37 R.S.A. 2000, c.A-3, s.3
38 Exhibit No. 01-003-2006-06-23

66. The Notice is that the Board has "undertaken a review" and "will consider" the "issue of legal entitlement" – not decide CBM ownership under private documents.

67. And if it is actually being suggested that the Board make a blanket or absolute determination that "natural gas" under any lease or grant includes CBM, the countless parties to them need be heard.[39]

68. Nor have there been the full procedural requirements usual in a civil determination of competing proprietary claims, and particularly discovery, which has long been established as key to a fair civil dispute resolution process.

69. Nor is the full record before the Board upon which to determine the competing claims of ownership here, let alone absolutely, given among other things:

a. as Devon acknowledged not all material on ownership is on the record;[39a]

b. Centrica had leases both reserving and granting petroleum;[39b]

c. Bearspaw obtained a lease of coal from a lessor who had none.[39c]

70. As in *Atco*, it would be unfair and inappropriate to decide a contentious issue as here without complete evidence.[40] Even if it could be said that the Board has the power to determine ownership, it ought to decline to exercise its discretion to do so.

V. <u>If the Board is to Decide CBM Ownership, it is the Coal Owners'</u>

71. EnCana has submitted that the Board has neither the power nor the record or parties to decide, but if it is to do so the balance of evidence on the record is that "coal" includes CBM as a constituent.

---

[39] 13-001-2006-08-25 FHOA Submission, para 12 noting that 40% of the freeholders own split title lands, and with the acknowledgment of Mr. Spiers that a number of his members own all mines and minerals which would include coal (611:18-20), that may be 60% of the 15,000 freehold owners.

[39a] 67:7-24

[39b] 556:25 *et seq.*

[39c] 123:19-125:21 regarding 02-019

[40] 2005 ABCA 226, para 20

72. Encana has submitted contemporaneous evidence that CBM was used by coal owners, and their responsibility for CBM necessarily implies control over it.

73. The CNG producers have submitted no contemporaneous evidence regarding "natural gas" for the early and mid 20th century which assists them and have not shown "coal" (under the grants) did not include CBM.

A. CNG producers have not established a legal construction that "natural gas" in situ, *in the contemporaneous vernacular, included CBM*

74. The CNG producers have led no evidence that the vernacular of "natural gas" *in situ* and before human interference would be understood to include CBM at the early and mid parts of the last century.

75. The CNG producers' evidence is that natural gas in the early part of the 20th century was a "worthless and noxious substance"[41] and that there was no CBM drilling by them until late in the century[42] – neither of which fact assists them.

76. Statutory definitions do not inform the issue of whether CBM is "coal" or "natural gas" here:[43]

a. they are not contemporaneous with the grants and leases;

b. none of the definitions in the *Oil and Gas Conservation Act*, the *Coal Conservation Act*, or the *Mines and Minerals Act* apply to leases or grants or restrict or address private party rights;

c. the Alberta legislature addressed entitlement to CBM in s.67 of the *Mines and Minerals Act*, but only with respect to lands where the Crown owns the mines and minerals; and

d. while the Alberta government is well aware of the split title issue, on both freehold lands and lands where the Crown owns only coal, a resolution has not been legislated.[44]

---

41 *Goodwell*, *supra* note 3, at para 34
42 See for example Devon 59:11-21
43 07-024-2006-09-15 EnCana Submission (Revised), paras 24-30
44 See for example Quicksilver 459:20-461:14, referencing Alberta Energy FAQ; MAC Report, July 2005, para 6.2 07-008-2005-07-27

77. Nor particularly does the decision in the American case of *Southern Ute* assist. It was decided on a statutory provision and seemingly to reflect settled industry expectations from a decade long reliance on a government opinion of the statute.

78. As recently said by the Appellate Court of Illinois in *Continental Resources* when considering the issue of CBM ownership there in the first instance, courts in other jurisdictions have struggled with the issues for more than a decade and a review of the cases reveals a split of authority.[45]

> No one answer is right for every state and/or every lease or grant. While cases from other states are helpful, we must make our own determinations based on Illinois law. And, in order to make those determinations, we must also consider fully the natural characteristics of coalbed methane gas and the methods, rights, and obligations of mining and extraction in general.[46]

And the court decided CBM was the coal owners' – notwithstanding *Southern Ute*.

79. There are no settled expectations as to the ownership of CBM in Alberta, and certainly none sufficient to determine the issue in favour of the CNG producers.

a. The CBM/NGC multi-stakeholder advisory committee, formed as part of a multi-phase review by Alberta Energy and involving multi-stakeholder and public consultations, concluded that:

> Where ownership is split, e.g., the Crown owns the coal rights and the P&NG rights are freehold, or vice versa, where two separate freehold owners exist, it is not clear who has ownership of the CBM/NGC.

b. Moreover, the evidence on the hearing was that:

---

45 *Continental Resources of Illinois Inc.* v. *Illinois Methane LLC* 87 N.E. 2d 897 (Ill. App. 5 Dist. 2006)
46 *Ibid.* at p 3
46a *supra*, at note 1
46b see for example: 455:8-19; 498:5-12
46c see for example 443:20-23; 444:7-9
46d see for example Apache Argument, para 11; Bearspaw Submission, para 13; 05-046 Devon letter discussed *infra* at para 128

i. the CNG producers acknowledged competing claims to CBM ownership;[46a]

ii. the CNG producers and the coal owners have made agreements to quiet title;[46b]

iii. the CNG producers drilled first on lands not subject to split title disputes;[46c] and

iv. parties recognize that the issue of ownership will not be resolved until the courts have decided it finally.[46d]

80. There is hardly a settled industry practice on CBM ownership[47], let alone one that might be seen as a custom sufficient to imply that "natural gas" includes CBM.

81. Nor does the evidence of Mr. Mavor support a construction that "natural gas" includes CBM, as his opinion that coal is but a container is founded on reasoning at odds with *Borys*, in that it reflects the state of affairs after human intervention and phase change.

82. Mr. Mavor reasons that because CBM comes out of the reservoir easily and is produced in a vapour phase, it is very similar and should be considered the same as gas from other types of rocks[48] – but that reasoning is at odds with *Borys*, as it concerns the reservoir after human interference.

83. As human interference by a well bore is required to significantly alter the properties of the primary and secondary porosity systems in the coal[49] (to permit gas flows from the higher density adsorbed state to a lower density producing well state)[50] the reasoning is of no avail here.

---

47 But that is the mischief of the CNG producers' position: Board, decide for us without regard for objections or with less than a full legal context, and then we can say to the courts "there is a settled practice" and you should not change it.

48 306:6-19; 18-001-2006-08-25 Mavor Report, p.20, para 2

49 18-001, Mavor Report, *ibid*. p.14, fifth paragraph

50 153:23-5. For a judicial consideration, see *Continental Resources* v. *Illinois Methane* 87 N.E. 2d 897 (Ill. App. 5 Dist. 2006) at 900, discussed *infra* at 90 *et seq*.

B. Coal owners have established a legal construction that "coal" in situ, in the contemporaneous vernacular, included CBM

84. The coal owners have led evidence that the contemporaneous *in situ* vernacular understanding of "coal" would include all of its constituents, including CBM.

85. As evidenced in EnCana's submission before the hearing, and in respect of which no contradictory evidence was called:

a. "coal" was known at the time to include CBM;[51]

b. CBM could have a commercial value at the relevant times, early and mid-1950s, to coal owners;[52]

c. CBM had no commercial value at the time to CNG producers,[53] and as they say it was "a worthless substance";[54]

d. the coal owners had the responsibility of dealing with CBM, as by venting it for safety purposes.[55]

86. "Coal" was not so narrowly understood and defined as the CNG producers suggest, as by *Southern Ute*: there were many more and broader definitions extant.[56]

87. Moreover, the leases suggest CBM was reserved as coal, as they require cementing to prevent flow of substances from one stratum to another,[57] which is inconsistent with a construction that all "gas" belongs to the CNG producers (as flow between stratum would then be irrelevant).

88. And if consideration of the common law principles is made in the context of the 21st century energy industry, as the Court of Appeal suggests,[58] the presumed

---

51 07-024-2006-09-15 EnCana Submission, paras 36-7
52 *Ibid*, EnCana Submission, paras 38-47
53 *Ibid*, EnCana Submission, paras 48-9
54 "Re mistaken belief in being valueless", note 41, *Goodwell, supra*, at 34
55 07-024-2006-09-15 EnCana Submission, paras 50-1
56 Report of Dr. Levine, p.50 *et seq.*
57 See for example 7-003-2005-04-13, EnCana letter to EUB, Tab C Petroleum and Natural Gas Lease, clause 11(c)
58 *Alberta Energy Corp.* v. *Goodwell Petroleum Corp.* discussed *supra* at note 3, para 81

intention of the parties must be that all in the coal belongs to the coal owner – otherwise, how is one to deal with *in situ* gasification of coals.

89. As said by the Privy Council in *Borys* when it considered an earlier claim by a CNG producer to gas in another substance (there, gas in solution) it is difficult to believe that the relevant parties would have differentiated between substances within the coal, and would have done anything other than understand that all in the coal belonged to the coal owner.

90. The 2006 considerations of the Illinois Appeals Court in *Continental Resources* are instructive:

> [5] Continental first alleges that oil and gas leases granting the right to produce all gases include the right to produce coalbed methane gas as well. As shown, coalbed methane gas is distinct, and the answer is not that simple. Each side has presented cogent arguments why coalbed gas should be declared the property of that particular side. Notable arguments include the fact that coalbed gas has practically the same chemical composition as natural gas with only very small percentages of other ingredients. On the other side, coalbed gas is a by-product of coal and has a natural and unique affinity for coal. The coal owner cannot mine the coal without removing the coalbed gas because it poses the perils of explosion and asphyxiation. In addition, coal owners need to control the production of coalbed gas in order to maintain the safety of the mines and the value of the coal seams,
>
> [6][7][8] Given the status of this case and the leases and land interests involved, we need not determine to whom the coalbed methane gas belongs in the absolute. We first note that the leases at issue here deny Continental the right to produce coalbed methane from a coal seam or void. The leases specifically require the lessee to permanently case and cement all holes drilled through coal seams or mine workings. The reservation of the right to drill through the coal does not include the right to drill into the coal and develop coalbed methane. We further note that the conveyance of coal as a distinct property also includes the bundle of property rights included within the coal, such as the rights incident and necessary to the recovery of the coal.

> If oil and gas leases included the right to develop coalbed methane, they then would also carry an implied right to invade the coal seams and stimulate them in a fashion that could make it more dangerous or difficult to later produce the coal. *Energy Development Corp.*. v. *Moss*, 214 W.Va. 577, 587, 591 S.E.2d 135, 145 (2003). Oil and gas producers have no direct interest in coal mine safety, and therefore coalbed methane gas historically has been completely controlled by whoever controlled the coal. We believe this to be a wise and just result. The control of coalbed methane gas should not change simply by virtue of its increased value. We further conclude that the bundle of property rights associated with the coal estate also includes the right to reduce to possession any gas trapped within the coal itself so long as the gas remains within that coal until the time of its capture. See *Vines* v. *McKenzie Methane Corp.*, 619 So.2d 1305, 1308 (Ala.1993); *United States Steel Corp.*, 503 Pa at 147, 468 A.2nd at 1383.

91. That reasoning applies well here, particularly noting the absence of any evidence as to "natural gas" at the material times.

C. CBM in situ *is a Constituent of Coal*

92. There is a single inexorable fact which establishes that CBM is a constituent of coal and not a separate gas: as Mr. Mavor said, more methane can be stored in the coal than would be possible by compression alone.[59]

93. If there is more CBM in coal than can be compressed into it, necessarily and logically CBM cannot be separate but must be part of the coal.

94. As Mr. Mavor acknowledged, the properties of a gas are dependent on pressure and temperature,[60] and thus the fact of more CBM in the coal than can be compressed into it means it is not a gas by his or any understanding.

95. And there is a second fact which makes it most difficult to argue CBM is not a constituent of coal: as Mr. Mavor said, the CBM is <u>physically bonded</u> on a molecular level to the coal.

---

[59] 20-013, Opening Statement of Mavor, p.4
[60] 385:10-386:14

96. It is illogical and unprincipled to argue that when two things are bonded they are not united or one or together. To do that, one needs ignore the fact of the bond and say they but touch.

97. By all accounts, the CBM is bonded to the entirety of the molecular surface of the coal – one molecule at a time – which suggests it is a constituent and part of the coal, unless of course the bond is ignored.

98. But even if the CBM within the coal is to be understood as separate from the coal, the experts agree that the density of its molecules in the adsorbed state is similar to the liquid density of the molecules,[61] with the result it cannot be a gas *in situ*.

99. While Mr. Mavor suggests that the density of the adsorbed CBM is similar to liquid it is nonetheless a gas,[62] that is inconsistent with his opinion that:

a. phase behaviour, which is the behaviour of vapour, liquid and solid as a function of pressure, temperature and composition, are generally identified by differences in density with density increasing from vapour to liquid to solid;[63] and

b. while the change in properties is gradual above the critical pressure and/or temperature, the fluid properties may be referred to as "liquid like at greater density and vapour like at lesser density".[64]

100. Moreover:

a. notwithstanding that the actual mechanism on how the gas is adsorbed is immaterial to Mr. Mavor, he had no authority cited for his opinion that "although the density [is] similar, the adsorbed gas is in the vapour phase";[65] and

---

61 18-001, Mavor Report, p.13, second last sentence; Levine Report and Direct Evidence, variously
62 *Ibid.*
63 *Ibid.*, p.11, second full paragraph
64 *Ibid.*, p.11, fourth paragraph
65 365:5-25

b. he didn't believe he expressed the opinion in any other writing or publication, noting that it was unusual for him to discuss in detail the state of the adsorbed state.[66]

101. As gases and liquids are distinguished by density, it is a stretch to distinguish two states or phases – free and adsorbed, with gas-like and liquid-like densities respectively – yet say both are nonetheless a gas or vapour.

102. It is to be recalled that Mr. Mavor had three reasons for his opinion that coal is a container for CBM: that it is produced like gas, that it is this "dense vapour"; and that CNG reservoir models apply.[67]

103. It is of no assistance to say that CBM is a gas simply because it is produced like CNG. Aside from the phase change required for that production as a gas, it begs the question to say CBM is a gas because it is produced like a gas; and CBM is also produced in other ways, as by in situ gasification and the means traditional to mining.

104. Moreover, the *Borys* and *Anderson* cases made clear that method of production is irrelevant to a determination of ownership, as shown by the fact that solution gas was held to be petroleum notwithstanding its production as CNG.

105. Nor is the second reason of Mr. Mavor, that CBM models consider coal as a gas storage container, of assistance to determination of the issue. Those models do not conclude that; the very premise of the models is that the coal is a container.[68]

106. The only reason of any relevance to the issue is that the CBM is a "dense vapour", but that reason is without authority and not previously said and is inherently inconsistent.

---

66 *Ibid*.
67 296:2-23
68 18-001, Mavor Report, p.20, last paragraph; 379:9-20

107. And it is on that reason which is found the only essential disagreement between Dr. Levine and Mr. Mavor. CBM in the coal *in situ* is for the former part of the coal and for the latter it is a gas, notwithstanding its density is greater than a gas.

108. To the extent that the evidence of the experts needs be weighed and one favoured over the other, which appears not necessary, EnCana submits it ought not to be Mr. Mavor's as the composition of coal and the mechanism of adsorption are subject matters with which he is admittedly not familiar (and in fairness to him he needs not understand as a reservoir engineer).

109. Mr. Mavor's focus and perspective are as a reservoir engineer,[69] and on what is needed to extract the substance and make predictions in that regard – but it is not on understanding coal or its constituents as he testified:

a. while the organic composition of coal is complex, it is not necessary for him to understand it to properly measure the data required to characterize the reservoir;[70]

b. he does not pay much attention to the chemical formula for coal, which is not a simple thing to define, because it is too complex and it is not something that he needs to do to understand a coalbed methane reservoir;[71]

c. while he understands water is inherent in coal and says it is part of it but he does not know what phase the water is in;[72]

d. nor does he know how the gas is stored, whether by adsorption or otherwise;[73]

e. when describing the attraction of the molecules to the pore walls and return to an adsorbed state, he acknowledges the data that he has pulled together as applied to coal has some problems with it and as the considerations are at the atomic level, he does not specifically know what is going on;[74]

---

69 305:8-23
70 167:25-168:4
71 327:25:7
72 330:6-10
73 331:15-332:4
74 351:18

f. because adsorption isotherm data is measured in the laboratory, "the actual mechanism on how the gas is adsorbed is immaterial" to his opinion;[75]

g. the state of the gas is, in the petroleum reservoir engineering community, not discussed very often, as they simply measure adsorption isotherms.[76]

110. Should the Board choose to weigh the evidence of the experts, EnCana submits that the evidence of Dr. Levine be accepted – as there is no doubt that he is extremely qualified and knowledgeable about the composition of coal and the mechanism of sorption; and the only criticism made of his opinion on a material point is easily refuted.

111. The CNG producers posit that CBM could not be gaseous in the coal and that Dr. Levine apparently supported such a position,[77] but that is not what the evidence is as discussed in detail in Appendix 1.

112. The CNG producers also criticize Dr. Levine's density estimates of CBM[78], but such assertions amount to nothing practical as Mr. Mavor describes the density of adsorbed CBM as "similar to liquid" and says "the fluid properties may be referred to as "liquid like".

113. Dr. Levine and Mr. Mavor concur on the material matters: most of the CBM is bonded to the coal on a molecular level, more is stored than can be compressed, and the bonded CBM has a density similar to or near liquid (in contrast to "vapour-like" for the balance of the CBM) – which evidence is dispositive that CBM is inherent in and a constituent of coal.

---

75 354:19-355:11
76 397:12-398:10
77 Joint Argument of CNG Producers, paras 24-30
78 Joint Argument of CNG Producers, paras 31-7

VI. Remedies

A. Cancellation of the Well Licenses is Mandated

114. EnCana sought review and variance here for the purpose of obtaining a cancellation of the licenses issued to Devon and Bearspaw.[79]

115. As there can be no entitlement without ownership, EnCana submits the licenses must be cancelled.

116. Quiet title before a license is not a "policy" as the CNG producers say, but a legal requirement as there can be no entitlement without it.

117. It is the Board's practice to require that, and not decide the issue – and has been for some time.[80]

118. And a legal requirement that title needs be quieted before drilling is the usual and expected course in other oil and gas jurisdictions, including Texas and Oklahoma.[81]

B. There is No Bar to Cancellation of the Well Licenses

119. Certain of the CNG producers appear to be suggesting that EnCana has changed its position on CBM ownership and on the Board's jurisdiction sufficient to disentitle it to relief.[82]

120. There has however been no change of position by EnCana on either the administrative or private law aspects of this matter and no CNG producer articulates a single legal reason why such would or could disentitle relief.

---

79 07-005, EnCana Submission for RNV
80 See *supra*, paras 41 and 42
81 64: 1-10, Devon and Apache
82 CJP reference Devon, Quicksilver, etc. See for example Bearspaw argument, p. 12 *et seq*; Devon argument, p. 3, *et seq*.

1. Public Law Does Not Bar Relief

121. Judicial review of an administrative action may be denied by a court as a mark of disapproval of an applicant's conduct,[83] but the applicants' allegations here are of a change of position by EnCana – which is not so – and there is no authority that disqualifies one from administrative relief.

122. EnCana has always said that not considering entitlement in granting the licenses on the mere assertion of "natural gas" entitlement is improper and to in effect decide the issue.

123. EnCana always and still says the Board must consider and determine "relative ownership of the parties"[84] – comparative ownership – and that the initial decisions here were made in error as such was not done.

124. And where, as here, there are competing claims – the Board cannot decide the dispute – and EnCana has never said to the contrary.

125. As said in EnCana's 25 November 2005 correspondence to the Board, the "errors" *inter alia* in issuing the approval to Bearspaw were:

> 2. Failing to expressly recognize the ownership claim of EnCana to CBM and the consequent dispute between it and Bearspaw over ownership and entitlement to the right to produce such; and
>
> 3. Failing to order that production be metered separately at the formations containing coal and that revenues associated with the disputed lands be paid to the Provincial Treasurer in trust pending court order or settlement by the parties.

---

[83] See Brown and Evans, *Judicial Review of Administrative Action in Canada* (Canvasback Publishing: Toronto, 1998) at 3-85-88

[84] See for example 31 January 2006 hearing transcript 46:3-13. Reproduced at Devon argument, para. 12.

126. The errors were failing to recognize the dispute, and failing to order payment of the money from the disputed lands to the Treasurer pending a court order or settlement – not failing to determine the dispute.[85]

127. EnCana's submission on Part 1 of the hearing also stated that production was not permissible where there is no undisputed entitlement, and that the Board is not authorized by statute to permit production in the face of an acknowledged ownership dispute.[86]

128. And it was not until receipt of the CNG producers' submissions for Part 2 of the hearing that it could even be suspected that they were seeking a Board determination of entitlement under the leases and grants.

a. Devon said from the outset and in responding to EnCana's objection that "the Board is not being asked, is not required by Devon's applications and for that matter, is not entitled to allocate property rights as among Devon, Luscar and EnCana".[87]

b. The Board in dismissing EnCana's objections said that:[88]

> Although EnCana and Luscar appear to invite the Board to engage in a debate on the issue of mineral ownership of CBM, the Board was of the view that it did not need to determine this issue in making its decision on the applications in question.
>
> ...
>
> As the EnCana and Luscar objections rest on the issue of CBM ownership ... the Board has dismissed its objections.

c. Devon first acknowledged an ownership dispute on the hearing to determine if review and variance would be granted,[89] and until its 25 August Submission was received, there was no suggestion that the

---

85 Paradoxically, Bearspaw sees this as a request that EnCana is asking the Board to adjudicate "property rights claims": 02-017; Bearspaw Submission, para 9

86 07-018-2006-06-09 Part 1 EnCana Submission, paras 18-24

87 05-046-2005-04-19 Devon letter re reply to Luscar and EnCana Submissions

88 01-005-2005-05-26, at p.4-5

89 Which was the very basis for the determination for this hearing: 9 March 2006 EUB letter

meaning and intent or the construction of "natural gas" in the leases or reservations would be at issue.[90]

d. And regarding Bearspaw, there was no issue as it accepts that the Board's position is that it will not determine property/ contractual disputes between industry participants.[91]

129. In sum, it appears the CNG producers misunderstood EnCana's legal position, and forgot that until 25 August 2006 they wanted "entitlement" based upon the mere assertion of "natural gas" ownership only.

130. Now Devon, along with some CNG producers, want a determination of entitlement under the leases[92] – unless they take the position that the Board has no right to adjudicate, and that approval should be given on the application alone, as Quicksilver and Bearspaw do.[93]

131. Before Devon's change of position and the suggestion from other CNG producers that the Board had the jurisdiction to decide the issue of ownership under the leases,[94] the issue had not even arisen and criticism for EnCana's response to it is ill-founded.

132. EnCana has but furthered its position in response to the CNG producers' varying submissions.

---

90 05-066, Devon Submission, paras 31-8

91 2-017, Bearspaw Reply Submission, para 18

92 Arguments of CNG producers: Apache, paras 26 and 31; Canpar Executive Summary, para 25 *et seq.*; Centrica, para 13; ConocoPhillips, para 8; Devon, paras 25-6; Fairborne, paras 18-19; and FHOA, para 40, apparently

93 CNG producers' arguments of CNG producers, Bearspaw paras 14 and 20; Quicksilver, para 27

94 Canpar said then that it did not intend under its agreement to sell CBM, para 7-9. ConocoPhillips contrasts various EnCana lease wordings, apparently to suggest a meaning of "natural gas" under one or the other, paras 15-20. Centrica said then that the law "dictates that the Board should give the terms "natural gas" and "coal" their plain and ordinary meaning in the vernacular under the subject leases, para 30. Fairborne then noted that the reservation in the leases is for "coal" which it said does not include gas stored in it, consistent with the definitions in the Board's legislation, putting in place the meaning of the leases, para 34).

2. Private Law Does Not Bar Relief

133. And insofar as the CNG producers suggest that a change in position as to the ownership of CBM is sufficient to determine the issue here, such a proposition is again without authority or principle.

134. Contractual rights, as provided by the grants and leases, may be varied, or waived, but the first requires an agreement supported by consideration, and the second requires an act in reliance on the asserted representation.[95]

135. Therefore, absent evidence of some natural gas owner in contractual privity with EnCana having agreed to a variation or relied upon a waiver of an entitlement to CBM, no heed can or needs be made to any of the CNG producers' assertions.[96]

136. And those assertions are belied by the evidence here:

a. each and all of the CNG producers knew fully well that EnCana disputed their claim to CBM and asserted that it belonged to EnCana;

b. EnCana did not accept the majority recommendation of CAPP on split title ownership issues for CBM, and supported a resolution that CBM not be legislated to be "natural gas";[97]

c. EnCana advised industry of its action against Trafina for trespass and conversion for taking CBM;[98] and

d. industry was also advised that "clearly we have *Borys/Anderson*" "applying a vernacular test with the *Borys/Anderson* gloss", and under a "CPR/Settler severance, CBM is coal".

137. EnCana submits that it would come as a great surprise if there were anyone under the impression that EnCana ever waived its claim that CBM was a

---

95 A.G. Guest, *Chitty on Contracts*, Vol. 1, (Sweet & Maxwell: London, 2004) at 1297-1304

96 And should it be suggested that any representation as to CBM ownership is evidence of the meaning of the words "coal" or "natural gas" under the grants or leases at issue, such would have no relevance unless made contemporaneous with the grants and leases (which certainly is not the case) and would be inadmissible as parol evidence.

97 20-066, CAPP Presentation

98 20-052, CBM split title in Alberta presentation, p.23 and 29

constituent of coal and belonged to EnCana – and there certainly is no evidence of that before this Board.

C. Continuation of Bulletin 2006-19

138. The maintenance of Bulletin 19 is consistent with the orderly development of CBM in Alberta, pending a judicial determination by the courts, as it but reflects the law and the practice of the Board.[99]

139. As noted in Williams and Meyers' *Oil and Gas Law*, any time a conflicting claim of title is made to minerals, development of the land becomes ultra-hazardous.[100]

140. Maintenance of the Bulletin is not in any fashion an injunction in favour of the coal owners, but a reflection of the practice of the Board[101] – no response to which was taken by any of the CNG producers.

141. The Bulletin gives no advantage to one party over the other in negotiations, neither has an undisputed ownership right which the other can frustrate.

142. And if the Bulletin is withdrawn, the consequence will simply be an objection by the coal owners wherever a CNG producer seeks to produce from coals.

D. Pooling and Reduced DSUs

143. EnCana seeks not to mandate pooling and reduced DSUs, by order of the Board or otherwise.

144. EnCana simply posits those as alternatives to lessen split title disputes.

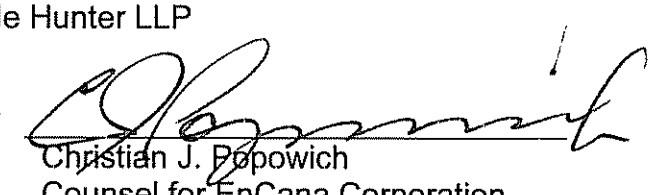
---

[99] *Supra*, paras 8 *et seq.* and particularly 41 and 42
[100] Williams and Meyers, *Oil and Gas Law*, December 2005, pub. 820, S225, cited in EnCana's submission at para 91
[101] *Supra*, paras 34, 41 and 42

145. If the CNG producers calculate the costs (which seem only to be metering and perhaps administration) as exceeding the benefits, so be it.

All of which is respectfully submitted this 30 day of November, 2006.

Code Hunter LLP

Per: 

Christian J. Popowich
Counsel for EnCana Corporation

APPENDIX

The critical temperature of pure methane is relevant specifically to describing the phase behaviour of pure methane, but not of CBM as it is not pure methane. Even the presence of water will complicate the phase behavior of pure methane.

As Mr. Mavor himself notes:[1]

> "Whitson and Brulé discuss the phase behavior of pure (one) component systems, multicomponent petroleum systems, and water in detail in a reference that is widely available to the petroleum industry. Figure 4 illustrates their pressure-temperature diagram for a one component system such as pure methane".

Whitson and Brulé also state:[2]

> "Strictly speaking, hydrocarbons and water should be treated simultaneously in phase behavior calculations" and "Because petroleum fluids are made up of many components, a detailed quantitative analysis is difficult to perform".
>
> ...
>
> "...for a single-component system, the two-phase region terminates at the critical point. In a multicomponent system, the two-phase region can extend beyond the system's critical point (i.e. at temperatures greater than the critical temperature and pressures greater than the critical pressure).

There is no doubt that any conclusion drawn from the phase diagram (exhibit 20-45) applies only to pure methane, and therefore not to CBM.

The Applicants state, incorrectly:[3]

> The critical temperature of methane is minus 82.6 degrees C and methane simply cannot exist as a liquid at temperatures that exceed its critical temperature.[4] Dr. Levine agrees.[5]

a) _____

1 *18-001 Mavor Report, p 11, 3rd para from bottom*
2 Whitson, C.H. and Brule, M.R.: Phase Behavior, Monograph Vol 20, Henry L. Doherty Series, Society of Petroleum Engineers, Richardson, Texas (2000) pp. 5 and 9
3 Joint argument of Natural Gas Rights Holders (page 4, Item 15)
4 Exhibit 20-013 Mavor Direct Testimony, page 2
5 920:20-921:2

While the Applicants are correct that the critical temperature of methane is -82.6°C, Dr. Levine disagrees with the balance of the statement as methane can exist as a liquid above that temperature in the presence of other substances.

First, the Applicant's own data demonstrate that methane can exist as a liquid well above the critical temperature of pure methane. The suite of phase boundary curves represented in Exhibit 20-045 depict the behaviour for various mixtures of methane and ethane as a function of temperature and pressure. Each specific methane-ethane mixture outlines the shape of a loop.[6]

- The high temperature, or right-hand side of the loop (the dew point curve) represents the range of temperatures and pressures below which a liquid phase will form.
- The area to the right of that dew point curve represents the gas phase region, where the mixture forms a homogeneous gas phase.
- The left-hand, or low-temperature side of the loop (the bubble point curve) represents the range of temperatures and pressures at which the liquid will boil.
- The area to the left of the bubble point curve represents the field of temperatures and pressures over which the particular methane-ethane mixture will form a homogeneous liquid phase.
- The area within the loop (two phase region) is where an ethane-rich liquid will co-exist with a methane-rich gas.

For a mixture of 50% methane – 50% ethane (Curve 6 on Exhibit 20-045), at 400 psia, the bubble point temperature is -95°F (-70°C). Below this temperature, the mixture will form a homogeneous liquid phase, 50% of which would be methane.

Significantly, both the bubble point and dew point for a 50/50 mixture of methane and ethane are above the critical temperature of methane -82.6°C (-116.7°F), despite the assertions of the Applicant that methane cannot exist as a liquid above the critical temperature. Either the Applicant's assertion is wrong, or the critical locus curve on their Exhibit 20-045 is.

Reference may also be made to the diagram from Whitson and Brulé (discussed by Dr. Levine)[7] depicting the apparent density of methane dissolved in various hydrocarbon liquids, at 14.7 psia, and 60°F. The caption of that diagram is "Apparent liquid densities of methane and ethane". The temperature of these measurements

a) _____

[6] See for explanation, Whitson and Brulé, *supra* note 2 at p 9, discussing the P-T curve and applicable concepts for single and multi-component systems

[7] Levine Direct Evidence, p. 10, bottom diagram, extracted from: Whitson, C H. and Brulé, M R.: Phase Behavior, Monograph Vol. 20, Henry L. Doherty Series, Society of Petroleum Engineers, Richardson, Texas (2000) p. 30

(15.6°C ; 60°F) is well above the critical temperature of pure methane, yet the liquid phases they are describing include methane, which is, therefore, a liquid.

Phase diagrams such as represented in Exhibit 20-045 are valid only in describing the behaviour of a distinct gas phase of the specified composition. This does not describe the behaviour of CBM in coal.

Second, it is a misrepresentation of Dr. Levine's testimony to state that he agrees that methane simply cannot exist as a liquid above its critical temperature, which apparently is based on the following:[8]

> Q: ...Nowhere in your report or your direct evidence or your testimony today have you said that sorbed methane exists in coal in an undisturbed reservoir as liquid, correct?
>
> DR. LEVINE: I quite carefully and intentionally did not call it a liquid because it's in the supercritical region. I try to be very careful with my use of language there. It is not liquid methane as is described on this methane phase diagram.
>
> Q. It can't be, can it?
>
> DR. LEVINE: No.
>
> Q. Because of the temperatures?
>
> DR. LEVINE: Correct.

Dr. Levine took great pains to specify that the phase behaviour of pure methane is different from that of methane in the presence of other substances. Dr. Levine's testimony makes this clear[9]:

> DR. LEVINE: So long as you understand the point that I made earlier in my direct testimony that these concepts [are] understood most clearly when discussing pure species. When you start dealing with mixtures, than [then] the critical point doesn't become a point. It can become a line through PTX space where you've added an additional dimension. I showed a two-dimensional graph, pressure and temperature, where the composition was constant. You add another component to the system and you've changed the physical behaviour of this system.

a) _____

[8] 920:15-921:2
[9] 896:16-897:1

Subsequently, Dr. Levine stipulates[10]:

> DR. LEVINE: Just so long as we've restricted our discussion *so far to a single-component gas or if you would like to* specify a gas mixture, I may wish to modify my answer; but if you're talking about pure methane, fine, I'm with you.
>
> Q. So far we re talking about pure methane.
>
> A. DR. LEVINE: Fine.

"So it [the critical point for pure methane] is depicted on this diagram as a unique point, [however] the critical point for methane describes only the pure methane system. It's very clear that we're not dealing with a pure methane system; not only are there mixtures of other gases present but methane is interacting with other constituents of the coal. So I question the very significance of looking at the phase behaviour of methane as a single component system."[11]

The cricondentherm (maximum temperature at which two phases can coexist) of a methane-ethane mixture describes the phase behaviour of a methane-ethane mixture as a gas phase, but is not helpful in understanding the sorption of methane-ethane mixtures in coal, for the same reasons that the pure methane phase diagram is not relevant.

> The phase behaviour of methane-ethane mixtures[12] demonstrates how the interaction between methane and other species alters the phase behaviour of pure methane.
>
> Depending on the relative proportion of methane and ethane, the critical temperature of the methane-ethane mixture varies continuously along a curved line between the critical temperature of methane (-82.6 °C; -116.7°F) and the critical temperature of pure ethane (+32.3°C; +90.1°F).

There is no substance to the CNG producers' assertion that it is "impossible for natural gas stored in coal to be a liquid", or that Dr. Levine agrees with such an assertion.

a) _____

[10] 897:12-22; see also page 921
[11] 823:12-19
[12] Exhibit 20-045 ("Phase Diagram of Methane-Ethane Mixture")

PHASE BEHAVIOR

Curtis H. Whitson
Professor of Petroleum Engineering
U. Trondheim, NTH
and
Founder
PERA a/s

and

Michael R. Brulé
President and Chief Executive Officer
Technomation Systems Inc.

First Printing
Henry L. Doherty Memorial Fund of AIME
Society of Petroleum Engineers Inc.

Richardson, Texas
2000

Chapter 1
Introduction

1.1 Purpose

This monograph covers a wide range of topics related to phase behavior. *Phase behavior* is the behavior of vapor, liquid, and solids as a function of pressure, temperature, and composition. In this monograph, "vapor" is used interchangeably with "gas," "liquid" refers to oil and water, and "solids" include hydrates, asphaltenes, and wax.

We are concerned primarily with the volumetric behavior and composition of phases, including density and isothermal compressibility, and component distribution in each phase. For a mixture with a known composition, we need to determine the vapor/liquid equilibrium (VLE), including saturation conditions over a wide range of temperatures and pressures. Transport properties are also needed for flow calculations (e.g., viscosity in Darcy's law and molecular diffusion coefficients in Fick's law).

Phase behavior has many applications in petroleum engineering. The reservoir engineer relies on pressure/volume/temperature (PVT) relations to calculate oil and gas reserves, production forecasts, and the efficiency of enhanced oil recovery (EOR) methods. Most reservoir calculations require PVT properties at reservoir temperature. Production engineers use phase behavior data for surface separator design and to calculate flow in pipe, where such calculations are made over a range of temperatures from surface to reservoir conditions. Petroleum engineering calculations generally are made at temperatures from 60 to 350°F and at pressures from about 15 to 15,000 psia.

1.2 Historical Review

Gibbs[1,2] and van der Waals[3] stated the basic theory of phase behavior in the the late 1800's and early 1900's. They formulated the concepts and mathematical relations necessary to describe phase behavior. Katz and Rzasa[4] published a comprehensive review of phase behavior literature from before 1860 to 1945. Muckleroy[5] published a bibliography covering 1946 to 1960, and other bibliographies exist for work in phase behavior over the past 30 years.*

Experimental data on reservoir fluids were scarce before the late 1930's, when Katz *et al.*[4,6-39] at the U. of Michigan. Sage and colleagues[40-73] at the California Inst. of Technology, and Eilerts *et al.*[74-78] at the U.S. Bureau of Mines (USBM) began significant research programs. For 10 years, during the 1950's, a large amount of high-quality experimental data was compiled on reservoir fluids. During the past 40 years, most phase behavior data have been measured by commercial service laboratories and major oil companies. These data have been used for engineering studies of primary depletion, waterflood evaluation, and gas-injection studies.

Correlation of phase behavior data began in the 1940's, with notable work by Standing and Katz,[17,18] Bicher and Katz,[25] Standing,[79,80] Eilerts,[78] Kennedy and colleagues,[81-85] and others. Although equations of state (EOS's) had been available for more than 50 years (since van der Waals[3] published the first cubic EOS in 1873) it was necessary to rely mostly on tables, figures, and chart correlations, such as nomograms. These correlations provided reliable property estimates for engineering calculations through the 1970's. Subsequently, empirical equations representing these graphical correlations were developed and programmed for calculators and computer applications.

With the introduction of electronic computers in the late 1940's, application of complicated thermodynamic models became possible. In 1949, Muskat and McDowell[86] published one of the earliest papers in the SPE/AIME *Transactions* on applications of this new generation of computers. These authors solved the two-phase flash calculation with fixed K values for multistage separator design.

Not until Redlich and Kwong[87] introduced their classic cubic EOS in 1949 was it generally accepted that volumetric properties could be accurately predicted by use of theoretical models. Considerable advances were made in the 1950's toward correlating volumetric properties of pure components with multiconstant EOS's.[88] By the early 1960's, there was considerable activity in the application of sophisticated thermodynamic models to multicomponent VLE calculations, although most of this activity was in process engineering.

In the 1960's and 1970's, Starling,[89] Soave,[90] and Peng and Robinson[91] proposed several important modifications of existing EOS's. Petroleum engineering EOS applications started seriously in the late 1970's and early 1980's, when EOS-based compositional reservoir simulators were introduced.[92,93] At the same time, several methods were proposed for EOS fluid characterization of reservoir fluids, in particular for heptanes and heavier components.[94-96] Finally, in the 1980's, supercomputers appeared and special solution techniques were developed for compositional simulators,[93] thereby making possible full-field, EOS compositional simulation.

Today's standard treatment of phase behavior in reservoir simulation is still based on formation volume factors (FVF's) and surface gas/oil ratios (GOR's). This will probably remain true for many years, in part because many problems can be solved adequately with a simple PVT formulation and in part because many petroleum engineers are not familiar with more complicated EOS models. This monograph treats both simple and complicated methods for estimating phase behavior. We suspect that the more complicated PVT

*SPE Reprint Series No. 15 *Phase Behavior* gives a recent update of earlier bibliographies.

Chapter 2
Volumetric and Phase Behavior of Oil and Gas Systems

2.1 Introduction

Petroleum reservoir fluids are naturally occurring mixtures of natural gas and crude oil that exist in the reservoir at elevated temperatures and pressures. Reservoir-fluid compositions typically include hundreds or thousands of hydrocarbons and a few nonhydrocarbons, such as nitrogen, CO_2, and hydrogen sulfide. The physical properties of these mixtures depend primarily on composition and temperature and pressure conditions. Reservoir temperature can usually be assumed to be constant in a given reservoir or to be a weak function of depth. As oil and gas are produced, reservoir pressure decreases and the remaining hydrocarbon mixtures change in composition, volumetric properties, and phase behavior. Gas injection also may change reservoir-fluid composition and properties. Katz and Williams[1] give an excellent review of reservoir fluids and their general behavior under different operating conditions.

The hydrocarbon phases and connate water sharing the pore volume (PV) in a reservoir are in thermodynamic equilibrium. Strictly speaking, hydrocarbons and water should be treated simultaneously in phase-behavior calculations. At typical reservoir conditions, the effect of connate water on hydrocarbon phase behavior can usually be neglected. Water can, however, affect the total-system phase behavior (for example, when hydrates form from natural-gas/water mixtures).

This chapter covers only two-phase, vapor/liquid phase behavior. Chap. 8 briefly covers three- and four-phase systems (vapor/liquid/liquid and vapor/liquid/liquid/solids) for low-temperature CO_2/oil and rich-gas/oil mixtures, and Chap. 9 gives the behavior of vapor and solids related to hydrates.

Sec. 2.1 introduces the composition of petroleum reservoir fluids and emphasizes their chemical complexity. Because reservoir fluids are made up of many components, a detailed quantitative analysis is difficult to perform. Organic compounds found in reservoir fluids are expressed by a general formula that classifies even high-molecular-weight compounds containing sulfur, nitrogen, and oxygen. This chapter also gives a historical review of the American Petroleum Inst. (API)-supported projects that defined many of the compounds known today.

Simple one- and two-component phase behavior can be helpful in describing the effects of pressure, temperature, and composition on the reservoir-fluid phase behavior. Sec. 2.2 presents pressure/temperature (p-T), pressure/volume (p-V), and pressure/composition (p-x) phase diagrams of simple systems. The behavior of these idealized systems is qualitatively similar to the behavior of complex reservoir fluids, as Sec. 2.3 shows.

Retrograde condensation is perhaps the most unusual phase behavior that petroleum reservoir fluids exhibit.* Sec. 2.4 discusses the definition of retrograde condensation and the effect of retrograde condensation on the behavior of gas-condensate reservoirs.

Petroleum reservoir fluids can be divided into five general categories, in increasing order of chemical complexity: dry gas, wet gas, gas condensate, volatile oil, and black oil. However, the phase behaviors of gas condensates and volatile oils are considerably more complex than those of black oils. The component distribution in a reservoir fluid, not simply the number of components, determines how close a fluid is to a critical state. Complex phase behavior is typically associated with systems that are "near critical": systems that usually contain 10 to 15 mol% of components that are heptanes and heavier (C_{7+}).

Since the early 1930's, experimental data have been measured on fluids of each type listed above. Sec. 2.5 defines each fluid type by its p-T diagram. Also, general characteristics of reservoir fluids are summarized in terms of composition and surface properties, such as GOR and stock-tank-oil gravity.

2.2 Reservoir-Fluid Composition

The nature and composition of a reservoir fluid depends somewhat on the depositional environment of the formation from which the fluid is produced. Geologic maturation also influences reservoir-fluid composition. Several theories offer explanations for the origin and formation of petroleum over geologic time; no single theory suffices to explain how oil and gas were formed in all reservoirs. One theory portrays reservoirs as giant high-temperature/high-pressure reactors with catalytic rock surfaces that slowly convert deposited organic matter into oil and gas. Other theories hypothesize that oil and gas were formed from bacterial action on deposited organic matter. Other investigators maintain that oil and gas may be formed in the same geologic formation but that each fluid migrates to "traps" at different elevations because of fluid-density differences and gravity forces.

Crude oil and natural gas are composed of many chemical compounds with a wide range of molecular weights. Some estimates[2-4] suggest that perhaps 3,000 organic compounds can exist in a single

*Historically, retrograde condensation has been considered the most complex phase-behavior phenomenon observed by reservoir fluids. Perhaps equally intriguing are the phenomena of strong compositional gradients, the condensing/vaporizing miscible mechanism (Chap. 6), asphaltene precipitation, and low-temperature, multiphase CO_2 behavior.

TABLE 2.2—DISTRIBUTION OF *h* SERIES FROM 698 TO 995°F DISTILLATE OF SWAN HILLS CRUDE OIL (Ref. 20)

Mass *h* Series	Probable Type
−12	Naphthalenes
−14	Naphthenonaphthalenes and/or biphenyls
−16	Dinaphthenaphthalenes and/or naphthenobiphenyls
−18	Trinaphthenaphthalenes and/or dinaphthenobiphenyls
−20	Tetranaphthenaphthalenes and/or trinaphthenobiphenyls
−22	Pentanaphthenaphthalenes and/or tetranaphthenobiphenyls
−24	Hexanaphthenaphthalenes and/or pentanaphthenobiphenyls
−26	Heptanaphthenaphthalenes and/or hexanaphthenobiphenyls
−28	Octanaphthenaphthalenes and/or heptanaphthenobiphenyls
−4S	Tricyclic sulfides
−6S	Tetracyclic sulfides
−8S	Pentacyclic sulfides
−10S	Hexacyclic sulfides
−8S	Thiaindanes/thiatetralins
−10S	Naphthenothiaindanes/thiatetralins
−12S	Dinaphthenothiaindanes/thiatetralins
−14S	Trinaphthenothiaindanes/thiatetralins
−10S	Benzothiophenes
−12S	Naphthenobenzothiophenes

is done when calculating compositional variation with depth, the phase rule is $F = n - P + 3$ [7]

2.3.1 Single-Component Systems. The *p-T* curve shown in **Fig. 2.4** is a portion of the vapor-pressure curve for a typical hydrocarbon compound. Above and to the left of the curve, the hydrocarbon behaves as a liquid; below and to the right, the hydrocarbon behaves as a vapor. Saturated liquid and vapor coexist at every point along the vapor-pressure curve. The curve ends at the critical temperature and critical pressure of the hydrocarbon (the "critical point"). **Fig. 2.5** shows a 3D PVT diagram of a pure compound.

The critical temperature of a single component defines the temperature above which any gas/liquid mixture cannot coexist, regardless of pressure. Similarly, the critical pressure defines the pressure above which liquid and vapor cannot coexist, regardless of temperature. Along the vapor-pressure curve, two phases coexist in equilibrium. At the critical point, the vapor and liquid phases can no longer be distinguished, and their intensive properties are identical.

For a multicomponent system, the definition of the critical point is also based on a temperature and pressure at which the vapor and liquid phases are indistinguishable. However, for a single-component system, the two-phase region terminates at the critical point. In a multicomponent system, the two-phase region can extend beyond the system's critical point (i.e., at temperatures greater than the critical temperature and pressures greater than the critical pressure).

Fig. 2.6[27] illustrates the continuity of gas and liquid phases for pure components. In this figure, the darker shading corresponds to higher density. A sharp contrast in phase densities is readily apparent along the vapor-pressure curve. As temperature increases along the vapor-pressure curve, the discontinuity becomes harder to discern, until finally, at the critical point, the contrast in shading is hardly noticeable. Qualitatively, the behavior described by the shading in Fig. 2.6 is the same for multicomponent mixtures in the undersaturated region.

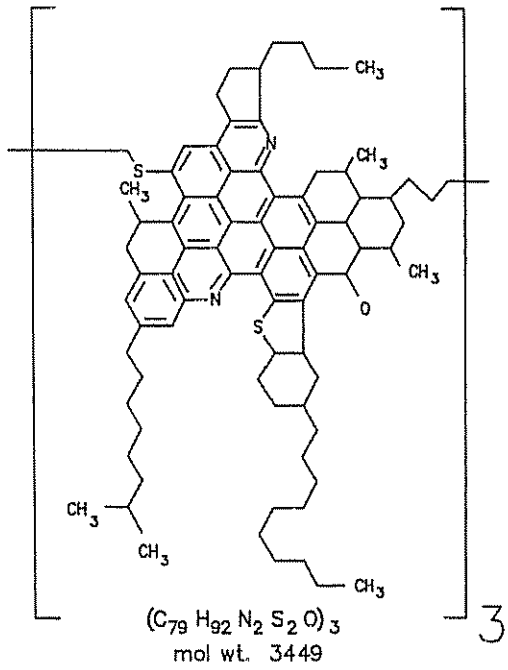


Fig. 2.3—Hypothetical structure of a petroleum asphaltene (after Speight and Moschopedis[14]).

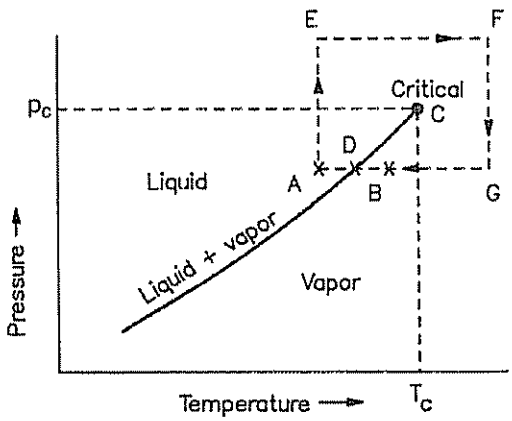


Fig. 2.4—*p-T* diagram for a single component in the region of vapor/liquid behavior near the critical point (p_c = critical pressure and T_c = critical temperature).

Phase changes do not have to take place abruptly if certain temperature and pressure paths are followed. A process can start as a saturated liquid and end as a saturated vapor, with no abrupt change in phase. The path D–A–E–F–G–B–D in Fig. 2.4 is an example of a process that changes phases without crossing the vapor-pressure curve. Pure components actually exist as a saturated "liquid" and "vapor" only along the vapor-pressure curve. At other pressures and temperatures, the component only *behaves* "liquid-like" or "vapor-like," depending on the location of the system temperature and pressure relative to the system's critical point. Katz[28] suggested calling a pure substance "single-phase fluid" at pressures greater than the critical pressure. Strictly speaking, the terms liquid-like and vapor-like should be used to describe undersaturated fluids.

cause the necessary data are not available. Sutton and Farshad[54] mention that the API correction for paraffinicity worsened bubblepoint predictions for gulf coast fluids. **Fig. 3.13** gives an explanation for this observation.

Fig. 3.13 shows the effect of paraffinicity (which is quantified by the Watson characterization factor, K_w) on bubblepoint pressure; the figure is based on calculations with a tuned EOS for an Asian oil (solid circles). The oil composition is constant in the example calculation. The 12 C_{7+} fractions are each split into a paraffinic pseudocomponent and an aromatic pseudocomponent (i.e., 24 C_{7+} pseudocomponents). The paraffinic fraction was varied, and bubblepoint calculations were made. The variation in paraffinicity is expressed in terms of the overall C_{7+} Watson characterization factor. Also shown in the figure are the variation in solution gas/oil ratio and the oil specific gravity with $K_{wC_{7+}}$.

The actual reservoir oil has a $K_{wC_{7+}} = 11.55$, where the EOS bubblepoint is close to the uncorrected Glasø bubblepoint prediction. When the correction for paraffinicity is applied, the correction gives a poorer bubblepoint prediction (even though the overall trend in bubblepoints is improved by the Glasø paraffinicity corrections).

A quantitatively similar correction to the Glasø correction (but easier to use) is based on the estimate for Whitson's[55,56] Watson characterization factor, K_w, and yields

$$(\gamma_o)_{\text{corrected}} = (\gamma_o)_{\text{measured}}(K_w/11.9)^{1.1824}. \quad \ldots\ldots\ldots\ldots (3.83)$$

The corrected specific gravity correlation is used in the Glasø bubblepoint correlation instead of the measured specific gravity. An estimate of K_w for the stock-tank oil must be available to use this correction.

Vazquez and Beggs[57] give the following correlations. For $\gamma_{API} \leq 30$,

$$p_b = \left[27.64\left(\frac{R_s}{\gamma_{gc}}\right)10^{\left(\frac{-11.172\gamma_{API}}{T+460}\right)}\right]^{0.9143}, \quad \ldots\ldots\ldots\ldots (3.84)$$

and, for $\gamma_{API} > 30$,

$$p_b = \left[56.06\left(\frac{R_s}{\gamma_{gc}}\right)10^{\left(\frac{-10.393\gamma_{API}}{T+460}\right)}\right]^{0.8425}, \quad \ldots\ldots\ldots\ldots (3.85)$$

with p_b in psia, T in °F and R_s in scf/STB. These equations are based on a large number of data from commercial laboratories. Vazquez and Beggs correct for the effect of separator conditions using a modified gas specific gravity, γ_{gc}, which is correlated with first-stage-separator pressure and temperature, and stock-tank-oil gravity.

$$\gamma_{gc} = \gamma_g\left[1 + (0.5912 \times 10^{-4})\gamma_{API}T_{sp}\log\left(\frac{p_{sp}}{114.7}\right)\right], \quad \ldots\ldots\ldots\ldots (3.86)$$

with T_{sp} in °F and p_{sp} in psia.

Standing's correlation can be used to develop field- or reservoir-specific bubblepoint correlations. A linear relation is usually assumed between bubblepoint pressure and the Standing correlating coefficient. This is a standard approach used in the industry, and the Standing bubblepoint correlating parameter is well suited for developing field-specific correlations.

Sometimes the solution gas/oil ratio is needed at a given pressure, and this is readily calculated by solving the bubblepoint correlation for R_s. For the Standing correlation,

$$R_s = \gamma_g\left[\frac{(0.055p + 1.4)10^{0.0125\gamma_{API}}}{10^{0.00091T}}\right]^{1.205}; \quad \ldots\ldots\ldots\ldots (3.87)$$

similar relations can be derived for the other bubblepoint correlations.

In summary, significant differences in predicted bubblepoint pressures should not be expected for most reservoir oils with most of the previous correlations. The Lasater and Standing equations are recommended for general use and as a starting point for developing reservoir-specific correlations. Correlations developed for a specific region, such as Glasø's correlation for the North Sea, should probably be used in that region and, in the case of Glasø's correlation, may be extended to other regions by use of the paraffinicity correction.

3.4.2 Oil Density. Density of reservoir oil varies from 30 lbm/ft^3 for light volatile oils to 60 lbm/ft^3 for heavy crudes with little or no solution gas. Oil compressibility may range from 3×10^{-6} psi^{-1} for heavy crude oils to 50×10^{-6} psi^{-1} for light oils. The variation of oil compressibility with pressure is usually small, although for volatile oils the effect can be significant, particularly for material-balance and reservoir-simulation calculations of highly undersaturated volatile oils. Several methods have been used successfully to correlate oil volumetric properties, including extensions of ideal-solution mixing, EOS's, corresponding-states correlations, and empirical correlations.

Oil density based on black-oil properties is given by

$$\rho_o = \frac{62.4\gamma_o + 0.0136\gamma_g R_s}{B_o}, \quad \ldots\ldots\ldots\ldots (3.88)$$

with ρ_o in lbm/ft^3, B_o in bbl/STB, and R_s in scf/STB. Correlations can be used to estimate R_s and B_o from γ_o, γ_g, p, and T.

Standing-Katz Method. Standing[3.17] and Standing and Katz[58] give an accurate method for estimating oil densities that uses an extension of ideal-solution mixing.

$$\rho_o = \rho_{po} + \Delta\rho_p - \Delta\rho_T, \quad \ldots\ldots\ldots\ldots (3.89)$$

where ρ_{po} is the pseudoliquid density at standard conditions and the terms $\Delta\rho_T$ and $\Delta\rho_p$ give corrections for temperature and pressure, respectively. Pseudoliquid density is calculated with ideal-solution mixing and correlations for the apparent liquid densities of ethane

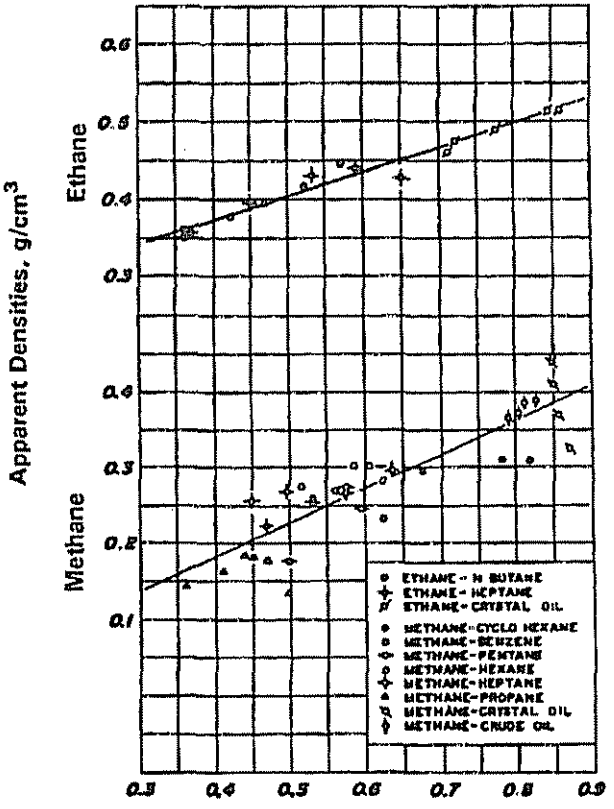


Fig. 3.14—Apparent liquid densities of methane and ethane (from Standing[33]).

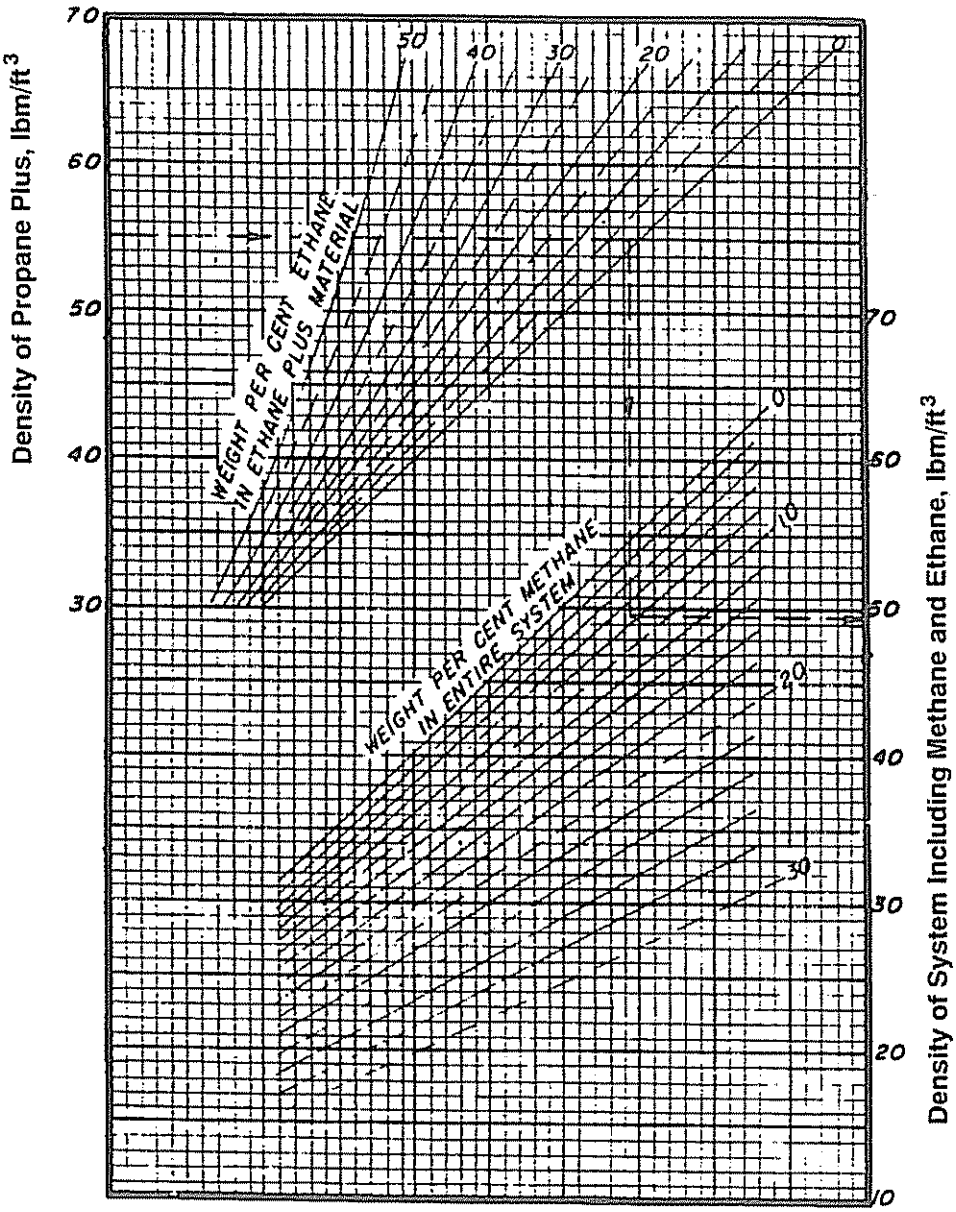


Fig. 3.15—Chart for calculating pseudoliquid density of reservoir oil (from Standing[33]).

and methane at standard conditions. Given oil composition x_i, ρ_{po} is calculated from

$$\rho_{po} = \frac{\sum_{i=1}^{N} x_i M_i}{\sum_{i=1}^{N} (x_i M_i / \rho_i)}, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.90)$$

where Standing and Katz show that apparent liquid densities ρ_i of C_2 and C_1 are functions of the densities ρ_{2+} and ρ_{po}, respectively (Fig. 3.14).

$$\rho_{C_2} = 15.3 + 0.3167\rho_{C_{2+}}$$

$$\rho_{C_1} = 0.312 + 0.45\rho_{po}, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.91)$$

$$\text{where } \rho_{C_{2+}} = \frac{\sum_{i=C_2}^{C_{7+}} x_i M_i}{\sum_{i=C_2}^{C_{7+}} (x_i M_i / \rho_i)}, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.92)$$

with ρ in lbm/ft³. Application of these correlations results in an apparent trial-and-error calculation for ρ_{po}. Standing[33] presents a graphical correlation (Fig. 3.15) based on these relations, where ρ_{po} is found from $\rho_{C_{3+}}$ and weight fractions of C_2 and C_1 (w_{C_2} and w_{C_1}, respectively).

Figs. 3.16 and 3.17 show the pressure and temperature corrections, $\Delta\rho_p$ and $\Delta\rho_T$, graphically. $\Delta\rho_p$ is a function of ρ_{po}, and $\Delta\rho_T$ is a function of $(\rho_{po} + \Delta\rho_p)$. Madrazo[59] introduced modified curves for $\Delta\rho_p$ and $\Delta\rho_T$ that improve predictions at higher pressures and temperatures. Standing[3] gives best-fit equations for his original graphical correlations of $\Delta\rho_p$ and $\Delta\rho_T$ (Eqs. 3.98 and 3.99), which are not recommended at temperatures > 240°F; instead, Madrazo's graphical correlation can be used. The correction factors can also be used to determine isothermal compressibility and oil FVF at undersaturated conditions.

The treatment of nonhydrocarbons in the Standing-Katz method has not received much attention, and the method is not recommended when concentrations of nonhydrocarbons exceed 10 mol%. Standing[3] suggests that an apparent liquid density of 29.9 lbm/ft³ can be used for nitrogen but does not address how the nonhydrocarbons should be considered in the calculation procedure (i.e., as part of the C_{3+} material or following the calculation of ρ_{C_2} and ρ_{C_1}). Madrazo indicates that the volume contribution of nonhydrocar-

TABLE OF AUTHORITIES

Otherwhere Reproduced

21. Oil and Gas Conservation Act ("OGCA") R.S.A. 2000, c. O-6

22. Alberta Energy Co. v. Goodwell Petroleum Corp., 2003 ABCA 277; Research Digest No. 33; Tab 4 EnCana Hearing II

23. Borys v. Canadian Pacific Railway (1953) 7 W.W.R. (N.S.) 546 (P.C.)

24. Anderson v. Amoco [2004] 3 S.C.R.

25. Anderson and Amoco Canada Oil and Gas, 1998 ABQB 620

26. Atco Gas & Pipelines v. Alberta (Energy and Utilities Board), 2006 S.C.C. 4

27. Williams and Meyers, Oil and Gas Law, December 2005, pub. 820, S225