IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re *Inter Partes* Review of:	)
U.S. Patent No. 7,228,904	)
Issued: June 12, 2007	)
Application No.: US 11/048,465	)
Filed: February 1, 2005	)

For: **Compositions and Methods for Improving Fracture Conductivity in a Subterranean Well**

FILED VIA E2E

DECLARATION OF DR. MUKUL M. SHARMA IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 7,228,904

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I. Introduction and Qualifications

1. I have been retained by Schlumberger Technology Corporation ("Petitioner") to provide my opinion concerning the patentability of U.S. Patent No. 7,228,904 (Ex. 1001, "the '904 patent") in support of this Petition for *Inter Partes* Review of U.S. Patent No. 7,228,904 (which is assigned to Halliburton Energy Services, Inc., "Halliburton"). I have also been asked to provide my opinion concerning the patentability of U.S. Patent No. 7,044,220 ("the '220 patent"), which is the parent of the '904 patent.

2. I have over 32 years of experience in the fields of hydraulic fracturing, oil and gas reservoir and production engineering, surface and colloid chemistry, and the application of materials such as polymers and surfactants to oil and gas production operations.

3. I received a Bachelor of Science degree in Chemical Engineering from the Indian Institute of Technology in 1980 and a Master of Science degree in Chemical Engineering from the University of Southern California in 1981. In 1985, I received a Ph.D. from the University of Southern California in Petroleum Engineering.

4. After graduating from the University of Southern California, I worked first as an Assistant Professor at the University of Texas at Austin between 1985 and 1990 and then as an Associate Professor between 1990–1995.

I was promoted to full Professor and "Tex" Moncrief Centennial Chair in 1995. I served as Chairman of the Department of Petroleum and Geosystems Engineering from 2001–2005.

5. During my tenure at the University of Texas at Austin, I have taught classes in and conducted research relating to, among other subjects, hydraulic fracturing, unconventional reservoirs, water management, formation damage, petrophysics, and natural gas engineering.

6. I have authored over 160 peer-reviewed journal articles and am a named inventor on over 20 issued patents and pending patent applications. I am the recipient of both the Lucas Gold Medal and the John Franklin Carl Award, the two highest technical awards presented by the Society of Petroleum Engineers. In 2018 I was elected to the National Academy of Engineering.

7. In 2007 I founded the Hydraulic Fracturing and Sand Control Joint Industry Project at the University of Texas at Austin, a consortium of oil and gas companies that funds research in hydraulic fracturing. This consortium is now in its 12th year and currently has over 20 projects related to hydraulic fracturing and fracturing fluids. I have co-founded two successful oil and gas companies and three oil and gas consulting and service companies. These companies have allowed me to be heavily involved in the practical application of technologies in the oilfield.

8. I have served as a consultant for over 40 oil, gas and service companies around the world.

9. My *curriculum vitae*, which includes a more detailed summary of my background, experience, and publications, is attached to the accompanying Petition as Ex. 1003.

II. Summary of Materials Reviewed and Considered

10. All of the opinions contained in this Declaration are based on the documents I reviewed and my knowledge and professional judgment. In forming the opinions expressed in this Declaration, while drawing on my experience in the field of hydraulic fracturing, I read and considered the ’904 patent, the parent patent (granted as the ’220 patent), and the prosecution histories of both, as well as any other material referenced herein.

11. My opinions are guided by my appreciation of how a person of ordinary skill in the art would have understood the claims of the ’904 patent at the time of the alleged invention, which I have been asked to assume is the 2003 time frame.

III. Background

12. The ’904 patent is related to hydraulic fracturing, and more specifically, to enhancing fluid flow from subterranean formations through

improved proppant matrixes. The following discussion provides background information about these well-known concepts.

13. Hydraulic fracturing (sometimes referred to as "fracking") has been used for approximately 70 years to increase the flow rate of natural gas and oil from reservoir rock formations by creating cracks in those rocks and rock formations. This process is often referred to as a method of "stimulating" an oil or gas well because—if successful—it stimulates production of natural gas or oil from the well. Fracturing may occur often far below the earth's surface (generally 2,000–5,000 m) and the goal is to create a more conductive path connecting a larger volume of natural gas or oil in the reservoir to the wellbore.

14. Hydraulic fracturing is accomplished by injecting fluid (the fracturing fluid) into subterranean rock formations at a pressure that fractures the rock. In short, the increase in hydraulic pressure creates a structural failure, and the newly-created fractures allow oil and gas to flow more freely. More specifically, fracturing fluids are injected into a formation at an injection rate such that the pressure of the fluid at the formation is higher than the pressure required to fracture the formation. This elevated pressure causes a crack or fracture to develop in the rock. Continued fluid injection into the well then causes the fracture to increase in size. The fracture is often initiated by a "pad" of fluid, which is followed by a fracturing fluid that often contains a proppant.

15. Proppants are particles (*e.g.*, sand) that will prop open the crack after hydraulic pressure is released and prevent the fracture from re-closing. As the fracture propagates into the rock, proppants are carried into the fracture by the fluid. After fluid injection has ceased, fracturing fluid flows out of the fracture, releasing the pressure, allowing the walls of the fracture to close on the proppant pack (sometimes referred to as a proppant matrix), which maintain some space for fluid flow between the particles. Since proppant particles are normally much larger than the particles of the formation, the permeability of the propped fracture is much greater than that of the formation. Thus, if successful, the conductivity of the propped fracture to fluid flow is much greater than the rock matrix and the well should produce more oil or gas.

16. Proppants must have a high compressive strength to support the formation stress and keep it propped open. Sometimes high-density, high-strength solids such as ceramics (such as bauxite) are used. Other well-known proppants include walnut hulls, natural sand, glass, resin-coated sand, and fused zirconia. Sand and ceramic proppants are the most common proppants used in fracturing.

17. Large-scale fracturing jobs can use thousands of barrels of fracturing fluids. Fracturing fluids are generally a blend of components, and must have

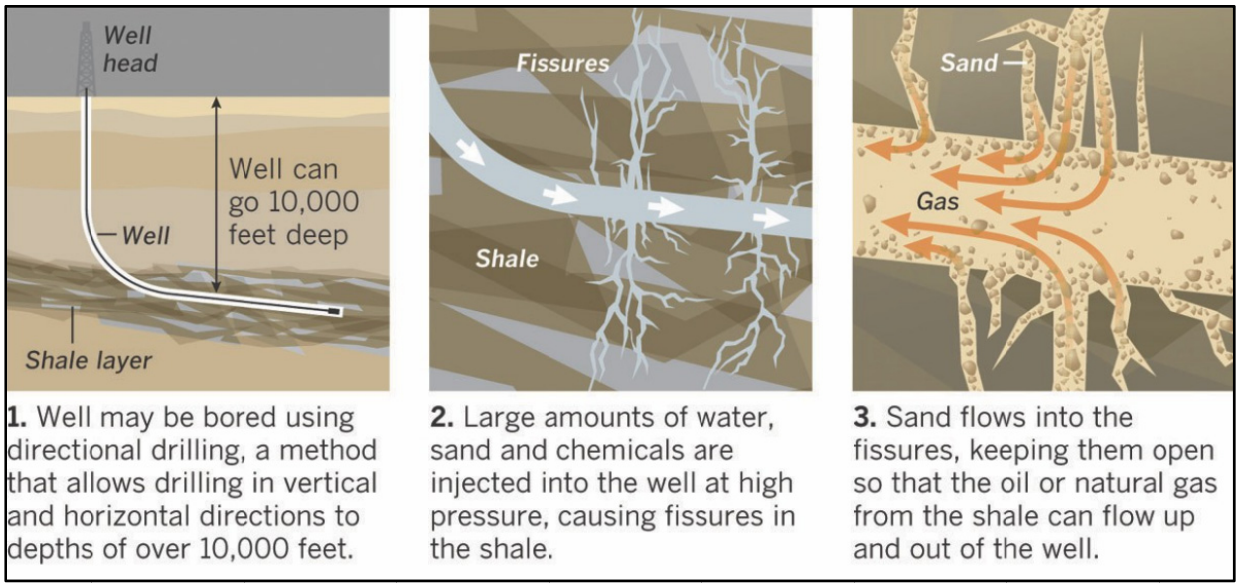
sufficient viscosity to open the fracture as well as to transport and distribute the proppant in the fracture.

18. The first hydraulic fracturing fluids were oil-based, and often included crude oil and/or gasoline thickened with components such as napalm. *See, e.g.*, Montgomery (Ex. 1011) at page 27, describing fracturing in the 1940s. Water was first introduced as a fracturing fluid in the 1950s, and the industry has steadily trended towards using water-based fluids rather than oil-based fluids for fracturing. *See, e.g.*, Holditch (Ex. 1016) at 959 ("the trend has been toward using water-based fluids rather than oil-based fluids for fracturing"). Water-based fracturing fluids were cheaper, easier to handle, and performed better. Water-based fracturing fluids generally require a gelling agent in order to achieve sufficient viscosity. Montgomery, at page 28. Guar gum and cellulose derivatives were used in this manner, often in combination with a cross-linker (a compound used to link polymers together). Generally once the formation has been fractured and the proppant is in place, it is desirable to remove the gelled fluid in order to allow the oil or gas to flow through. This is referred to as "breaking" the gelled fluid.

19. Numerous patents describe this breaking process and various improvements thereof. For example, U.S. Patent No. 5,226,479 to Gupta (Ex. 1012) describes the process of using a breaker in order to break down the viscous

fracturing fluid, and summarizes various processes known in the art, such as using enzyme preparations to break down guar gum. For example, guar gum fluids can be broken with enzyme preparations. Gupta, 1:55–2:61. Gupta goes on to describe an improved enzyme breaker that is active only at certain pH levels, allowing for a greater degree of controllability (a generally desired feature). Gupta, 3:26–40. The '904 patent also lists several examples of this type of technology on the face of the patent, such as U.S. Patent No. 5,591,700 (Ex. 1014) and U.S. 6,214,773 (Ex. 1015) to Harris (both also assigned to Halliburton).

20. A simplified version of the fracturing process is shown below:



21. The degree to which a well is stimulated by the fracturing process is largely dependent on the permeability, length, and width of the propped fracture.

Thus, the productivity of the well is a function of the fracture's conductivity. '904 patent, 1:27–36.

22. Accordingly, although the basic fracturing process has remained largely unchanged for decades, various improvements are continuously being made. For example, because sand is not capable of withstanding the high closure stresses encountered in some formations, higher-strength ceramic proppants were introduced to the market.

23. It is an old practice to consolidate proppant in a fracture, forming a proppant matrix that holds the fracture open so that oil (or gas) may be recovered from the formation. Watanabe, 1:30–36 (describing "the fundamental process of hydraulic fracturing treatment"); Card, 1:37–45 (gradually releasing pressure "so that fracture closure pressure acting against the proppant builds gradually allowing proppant matrix to stabilize before fracturing fluid flowback and well production can carry significant quantities of the proppant out of the fractures."). And, as would be known to a person of skill in the art, proppant particles can form an agglomeration or consolidation in a formation, resulting in a proppant matrix because of the closely-associated particles. For example, the pressure applied by the rock on the fracture can create an agglomeration of proppant particles, as can Van der Waals or electrostatic forces.

24. But, because sand used in fracturing can be friable, it may be crushed under the stresses deep in the earth, resulting in fines (small particles) that may flow back into the wellbore. In fact, the proppant particles themselves may flow back into the wellbore if the flowback fluid velocities are high enough. Resin-coated proppants were developed so that when the resin cures downhole, the proppant still remains in place in the fracture. Resin-coated proppants have been used for decades. *See, e.g.*, U.S. Patent No. 5,501,274 to Nguyen (Ex. 1013). Nguyen describes resin-coated proppants and other ways to secure proppant particulates together, such as using thermoplastics. Nguyen, 1:41–2:23. The most common resins used to coat proppants are epoxy resins, furan, polyesters, vinyl esters, and polyurethane, all well-known in the art.

25. The main advantage of resin-coated proppant is that the resin coating can consolidate proppant particles preventing proppant flowback into the wellbore. This consolidation also creates a "proppant matrix."

26. Other methods of creating proppant matrixes were also well-known in the art, such as using a tackifying agent to help the proppant particles consolidate. Nguyen also describes using a thermoplastic to help create a proppant matrix to prevent particulate flowback. Nguyen, 2:47–65.

27. It was also well-known in the art to create proppant matrixes by using fiber-assisted proppant transport where the proppant forms stable packs or

matrixes with the fiber without decreasing permeability or conductivity. *See, e.g.*, Palmer, 1:31–45 ("…The inventions of these patents are characterized by the use or presence of particulate materials and various solid materials, *with emphasis on the formation of matri[x]es of solid material and particulate material, or "packs," in the formation*. *Included among the wide variety of solid materials disclosed which may be employed in forming a pack or matrix are various types of fibrous materials*, such as fibers of glass, ceramic, carbon, natural or synthetic polymers, or metal filaments. Important aspects of the procedures employed are the formation of stabilized matri[x]es and prevention of proppant flowback from the subterranean formations"); *see also* claims 4 and 11.

28. The '904 patent admits that proppant matrixes were well-known, describing them in the specification under the heading "Background of the Invention." '904 patent, 1:37–46 (for example, recognizing resin-coated proppant particulates as "conventional" technology). The '220 patent also admits that proppant matrixes are prior art under the heading "Description of the Prior Art." '220 patent, 1:14, 1:31–39 ("Oftentimes, to effectively prop open the fractures as well as prevent proppant particulate flowback, the proppant particulates are caused to consolidate into proppant matrixes within the fractures.").

29. Although creating proppant matrixes has advantages, this approach may also negatively affect permeability (and thus conductivity) of the fracture. Accordingly, various efforts have been made to increase the permeability of the proppant matrixes to retain and enhance their conductivity.

30. The '904 patent describes two well-known approaches to improve the conductivity and permeability afforded by a particular proppant matrix. As one example, calcium carbonate or salt is added to the proppant, and after fluid is added to the wellbore, the calcium carbonate or salt is dissolved out of the matrix, leaving channels or voids in the matrix. As another example, wax beads have been added to proppant compositions, and the wax melts out of the proppant matrix as a result of the higher temperature in the formation. Although these approaches are partially successful, both have problems associated with incomplete removal of the non-proppant component. '904 patent, 1:57–2:7. Accordingly, those skilled in the art continually experiment with new materials.

31. Another common approach to improve conductivity is to break the gelled fracturing fluid, as noted above. This technique also increases the permeability of the proppant matrixes when the gelled fluid is broken. *See, e.g.*, Gupta, 1:57–59 ("it is desirable to remove the [gelled] fluid from the formation to allow hydrocarbon production through the new fractures").

32. It was also known in the art to use a degradable material in place of a gelled or highly viscous fluid, such that voids or channels would be left in the proppant matrix when the degradable material degrades. For example, Union Oil Co. developed and commercialized "Unibeads" at least as early as 1965 (see article describing Unibeads at Ex. 1007). Unibeads were composite "beads" made of a petroleum-wax base with other polymers and chemical additives mixed in. The beads were useful as plugging agents, but were also taught as suitable for mixing with propping agents to "guarantee a partial monolayer" when forced into the created fracture, solving the problem of where 'the propping agents will congregate to produce a solid mass which blocks fluid entry into the well bore." Unibeads, 54. After the beads degrade, they leave "a pattern of open spaces between the sand grains, glass beads or other propping agents, to guarantee free passage to reservoir fluids." Unibeads, 54.

33. As another example, U.S. Patent No. 3,173,484 to Huitt (cited during prosecution history of the parent '220 patent, Ex. 1005) describes introducing a fracturing fluid containing two different types of particles. Both initially assist with propping open the fracture, and then one type of particle is removed, providing spacing between the remaining proppant particles and creating highly permeable flow channels. Huitt, 1:50–63. Removal can occur by a number of different mechanisms, depending on the physical and chemical

properties of the particle to be removed. Huitt, 2:3–11. Huitt notes that choosing a particle that can be degraded by dissolution in either oil or water (which are likely to be present in the formation) is beneficial. Huitt, 2:37–51.

34. U.S. Patent No. 6,328,105 to Betzold (cited during prosecution history of the parent '220 patent, Ex. 1006) also describes a proppant composition containing bondable particles (which adhere to each other and form a matrix) and removable particles, which increase conductivity upon their removal. Betzold, 2:33–48. The removable particles are selected to have a size, shape, and density similar to the size, shape, and density of the bondable particles. Betzold, 2:48–54. The removable particles are selected to remain substantially intact during fracturing but will later dissolve or decompose and be substantially removed. Betzold, 3:42–4:14. Betzold also teaches that two or more different types of removable particles can be used. Betzold, 4:40–48.

35. Improvements were also made with regard to particular degradable materials. For example, U.S. Patent No. 4,387,769 to Erbstoesser (Ex. 1018) details the degradation characteristics of D, L-polylactide at length. Erbstoesser, 3:4–7; 4:56–63; Examples 4–11. Notably, Erbstoesser highlights the desirability of controlling the degradation characteristics of a material used in various oil and gas applications. Erbstoesser, 3:54–59; 4:62–5:25. Those skilled in the art were (and are) continually seeking improved controllability of materials, particularly

for applications such as increasing the permeability and conductivity of a proppant matrix.

36. As is apparent, the concept of using a degradable material intermixed with proppant in order to increase permeability and conductivity of the resulting proppant matrix was well-known in the art long before June 2003, which I understand is the earliest possible priority date of the '904 patent.

IV. THE '904 PATENT

37. The '904 patent is directed to precisely this same issue: enhancing fluid flow from proppant matrixes in formations by using a proppant composition containing (i) a proppant in combination with (ii) composite particles comprising a degradable material and a filler material. The degradable material is capable of degrading when in position in the formation, creating voids (*i.e.*, empty spaces) in the proppant matrix by its removal. '904 Patent, 2:26–40. The filler material is simply another material included in the composite particle that may serve many purposes, several detailed below, and preferably complements the degradable material. '904 Patent, 9:65–67.

38. According to the '904 patent, "[a]ny proppant particulates suitable for use in subterranean applications are suitable for use in the compositions and methods of the present invention," including both resin-coated and uncoated proppant particles such as natural sand. '904 Patent, 4:10–23. The proppant

particulates form a proppant matrix, which the '904 patent defines as "a consolidation of proppant particulates within a fracture that may be adjacent to a well bore in a subterranean formation." '904 Patent, 3:24–26. This is generally consistent with how a person of skill in the art would understand the term "proppant matrix" as encompassing any closely-associated groups of proppant particles. And as noted above, proppant matrixes were well-known in the art, and the '904 patent recognizes that proppant matrixes can be achieved by "conventional" technology. '904 patent, 1:37–46.

39. The proppant matrix can be formed by any suitable mechanism, including resin coatings or tackifying agents, as well as interlocking particles. '904 Patent, 3:27–33. But, as would be known to a person of skill in the art and explained above, even an uncoated proppant particle can form an agglomeration or consolidation in a formation, resulting in a proppant matrix because of the closely-associated particles. *See, e.g.*, Huitt, 1:35–44; Watanabe, 1:30–36; Card, 1:37–45. The pressure applied on the proppant particles by the stresses in the earth can create an agglomeration, as can Van der Waals or electrostatic forces.

40. The '904 patent takes an expansive definition of what constitutes a "degradable" material.

41. For example, the '904 patent explains what "degradable" or "degradation" means, saying it refers "to at least the partial decomposition of the

degradable material, and includes both homogenous and heterogeneous forms of degradation. This degradation can be the result of, for example, a chemical or thermal reaction, or a reaction induced by radiation." '904 Patent, 7:23–29.

42. The composite particles preferably are to have a size and shape similar to that of the proppant particulates to help maintain uniformity, although a specific size or shape may be chosen for a particular application. '904 Patent, 10:1–11:20.

43. The degradable material can be a degradable polymer. '904 Patent, 7:55–59. Suitable polymers include various polymers known in the art, although aliphatic polyesters (such as poly(lactide)) are preferred. '904 patent, 8:19–46.

44. As noted above, the filler material is simply another material included in the composite particle that may serve many purposes. The filler can enhance the mechanical properties of the composite particles or may react with degradation products (such as by neutralizing a resulting acid). '904 Patent, 9:36–63. Some fillers are also degradable materials. '904 patent, 10:1–21. Preferably, the filler material should complement the degradable material. '904 patent, 9:64–67. The filler can also be an inert filler material that enhances the compressive strength of the proppant matrix. '904 Patent, 11:39–44. Regardless of its function, the filler material may comprise from about 0.5% to about 60% of the composition of the composite particle. '904 Patent, 9:41–45.

45. The concentration of the composite particles in the proppant composition ranges from about 0.1% to about 30% based on the weight of the proppant particles in the composition, and should not be so high as to leave an undesirable percentage of voids when degraded, potentially damaging the integrity of the proppant matrix or the fracture. '904 Patent, 11:55–12:3.

A. The '904 Patent Claims

46. The '904 patent has 20 claims with three independent claims (reproduced below for convenience).

47. Claim 1 recites:

> **1.** A method comprising:
>
> providing a proppant matrix composition, the proppant matrix composition comprising at least a plurality of proppant particulates and at least a plurality of composite particles, the composite particles comprising a degradable material and a filler material;
>
> introducing the proppant matrix composition into a fracture in a subterranean formation so as to form a proppant matrix in the fracture; and
>
> allowing the degradable material of the composite particles to degrade so as to form at least one void in the proppant matrix.

48. Claim 14 recites:

> **14.** A method comprising:
>
> providing a proppant matrix composition, the proppant matrix composition comprising at least a plurality of proppant particulates

and at least a plurality of composite particles, the composite particles comprising a degradable material and a filler material;

allowing the proppant matrix composition to form a proppant matrix;

allowing the degradable material of the composite particle to degrade so as to form a void in the proppant matrix; and

allowing a fluid to flow through the proppant matrix.

49. Claim 19 recites:

19. A method comprising:

providing a treatment fluid that comprises a proppant matrix composition, the proppant matrix composition comprising at least a plurality of proppant particulates and at least a plurality of composite particles, the composite particles comprising a degradable material and a filler material;

contacting at least a portion of a subterranean formation with the treatment fluid under conditions effective to create or enhance at least one fracture in the subterranean formation; and

allowing the proppant matrix composition to form a proppant matrix having at least one void therein.

B. The '904 Patent Prosecution History

50. I reviewed the prosecution history of the '904 patent (Ex. 1020) and the prosecution history of its parent, the '220 patent (Ex. 1004). I understand the prosecution history of the parent is considered part of the prosecution history of the '904 patent, and thus discuss both below. Although I am not a patent

attorney, I have a general understanding of patent prosecution and the significance of the prosecution history because I am a named inventor on numerous patents and patent applications.

51. The prosecution history of the ’220 patent is short, as it was allowed after only a single office action. I provide a high-level summary below.

52. The PTO issued an Office Action on May 17, 2005 rejecting the claims over numerous references, including Betzold. Huitt was also noted to be cumulative to the references applied, and the Applicant was requested to distinguish over Huitt in addition to the references used for the rejections.

53. In the amendment made September 7, 2005, independent claims corresponding to claims 1 and 20 were amended to specify that the degradable material comprises one or more poly(orthoesters). Ex. 1004, 36–43. Numerous new claims were also added. An amendment was later made to claim 39 to specify poly(orthoesters) as well. Ex. 1004, 7.

54. In order to overcome the references, Halliburton argued that none of the references teach degradable materials in the form of poly(orthoesters). Ex. 1004, 45–54.

55. Halliburton also argued that the references do not teach composite degradable materials as defined in the application as a degradable material formed by mixing with an inorganic or organic compound. Ex. 1004, 45–54.

The Examiner appears to have been persuaded by this argument, and a notice of allowance was subsequently issued.

56. The prosecution history of the ’904 patent is short, as it was also allowed after only a single office action. I provide a high-level summary below.

57. The PTO issued an Office Action on December 20, 2006 rejecting some claims based on the format of the claim language. Ex. 1020, 27–30. No prior art rejections were made.

58. In order to overcome the rejection, Halliburton amended certain dependent claims to recite “consisting of” in place of comprising. Ex. 1020, 15–23. I have been informed that the significance of this language is that the claims should be interpreted as including a list of alternatively useable options. A notice of allowance was subsequently issued.

C. Errors in Prosecution History

59. I understand that the ’220 patent was allowed over cited references Cooke, Betzold, Atkins, and Huitt (though Huitt was not formally applied). Ex. 1004, 169–177. It appears as though the applicant overcame these rejections by arguing that none of the references teach (i) poly(orthoesters) (a limitation added to independent claims 1, 20, and 39), or a composite material as defined in the ’220 patent (relevant to claims 39–73). Ex. 1004, 44–54. The applicant did not

substantively address the disclosures the Examiner pointed to in *any* of the references.

60. Notably, the Applicant made no argument at all regarding Huitt, although the Examiner indicated that Huitt was cumulative to the cited references and any amendment to the pending claims "must distinguish over Huitt…as well." Ex. 1004, 177.

61. But, I believe that the disclosures of these documents are highly relevant to the claims of the '220 patent (particularly Betzold, where the Examiner made a clear error as discussed below). And, given the similarity of the claims between the '220 and '904 patents, these documents are also relevant to the claims of the '904 patent. For example, each reference generally teaches a process of fracturing and propping a subterranean formation with a proppant matrix where a degradable material is ultimately removed from the matrix, resulting in voids and increased conductivity. Thus, these references are still very relevant to determining the patentability of the '220 and '904 patents, particularly when considered in combination with additional references that were not before the Examiner in the '220 patent (and no references were considered by the Examiner in the '904 patent).

62. For example, it appears that the Examiner made a critical error when evaluating Betzold. Ostensibly claims 56–73 of the '220 patent were allowed

based on their reference to a composite material (because they do not recite poly(orthoester)). But, Betzold discloses that its removable particles *can be composites*, noting that they can include dissolvable metals (*i.e.*, an inorganic compound) or various additives, consistent with the definition in the ’220 patent. Betzold, 3:67–4:15. These composites also meet the definition of the ’904 patent, as they include a degradable material and a filler. Thus, it appears as though claims 56–73 of the ’220 patent should not have been granted in view of Betzold’s disclosure, and the Examiner’s allowance of these claims was in error. Similarly, claims 1–20 of the ’904 patent (which also recite composites) should not have been granted over this reference.

V. Relevant Legal Principles

63. I understand that a prior art reference can render a patent claim obvious to a person of skill in the art if the differences between the subject matter set forth in the patent claim and the prior art are such that the subject matter of the claim would have been obvious at the time the claimed invention was made. I understand that obviousness is a legal conclusion, but I am not offering a legal conclusion. I am testifying regarding the relevant facts that underlie the legal conclusion: the level of skill in the relevant art, the scope and content of the prior art, the differences between the prior art and the claims, and any secondary considerations.

64. I understand that when the claimed subject matter involves combining pre-existing elements to yield no more than one would expect from such an arrangement, the combination is obvious. I understand that in assessing whether a claim is obvious one must consider whether the claimed improvement is more than the predictable use of prior art elements according to their established functions. I understand that there need not be a precise teaching in the prior art directed to the specific subject matter of a claim because one can take account of the inferences and creative steps that a person of skill in the art would employ. I understand that a person of ordinary skill is a person of ordinary creativity, not an automaton.

65. I understand that obviousness cannot be based on the hindsight combination of components from the prior art. I understand that in an obviousness analysis, neither the motivation nor the avowed purpose of the inventors controls the inquiry. Any need or problem known in the field at the time of the invention and addressed by the patent can provide a reason for combining elements. For example, I understand that it is important to consider whether there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent's claims. I understand that known techniques can have obvious uses beyond their primary purposes, and

that in many cases a person of ordinary skill can fit the teachings of multiple pieces of prior art together like pieces of a puzzle.

66. I understand that, when there is a reason to solve a problem and there are a finite number of identified, predictable solutions, a person of ordinary skill has good reason to pursue the known options within his or her technical grasp. I understand that, if this leads to the anticipated success, it is likely the product not of innovation but of ordinary skill and common sense, which bears on whether the claim would have been obvious.

67. I understand that secondary considerations can include, for example, evidence of commercial success of the invention, evidence of a long-felt need that was solved by an invention, evidence that others copied an invention, or evidence that an invention achieved a surprising result. I understand that such evidence must have a nexus, or causal relationship to the elements of a claim, in order to be relevant.

68. I am not aware of any secondary considerations applicable to the subject matter of the ’904 patent, and have not provided any opinions related to secondary considerations at this time. If Halliburton provides any evidence of secondary considerations, I will evaluate it at that time.

VI. Level of Skill in the Art and Perspective Applied in this Declaration

69. I understand that certain issues relating to patentability must be judged from the perspective of a person of ordinary skill in the relevant art.

70. The invention of the ’904 patent relates to methods of hydraulic fracturing. At the time of the alleged invention, a person of skill in the art would typically have at least a bachelor’s degree in petroleum, mechanical, or chemical engineering and several years of experience working with proppants. This description is approximate, and a higher level of education or skill might make up for less experience, and vice-versa.

71. I believe that I would have qualified as a person of at least ordinary skill in the art as of the claimed 2003 priority date of the ’904 patent, and I believe that I have a sufficient level of knowledge, experience, and education to provide an expert opinion in the field of the ’904 patent. Also, I have supervised many persons of ordinary skill in the art as of the relevant time frame, and I am familiar with their capabilities.

72. My opinions in this Declaration are based on the perspective of a person of skill in the art in the 2003 time frame. This is true even if the testimony is stated in the present tense.

VII. Claim Construction

73. I have been asked to offer opinions related to the construction of certain terms in this analysis. I understand that in this proceeding, a patent claim receives the broadest reasonable construction in light of the specification of the patent in which it appears. I understand that in this proceeding, any claim term that is not construed should be given its plain and ordinary meaning under the broadest reasonable construction. I understand that the "broadest reasonable construction" standard applicable to this proceeding is not the same as the claim construction standard applied in district court litigation. I have followed these principles in my analysis below.

74. The following table summarizes the terms I have construed and the constructions I have adopted.

Claim Term	Proposed Construction
"***degradable material***" (claims 1–20)	"Any material capable of at least partially degrading downhole by any mechanism."
"***proppant matrix***" (claims 1–20)	"A consolidation of proppant particulates within a fracture in a subterranean formation."

A. "degradable material"

75. Independent claims 1, 14, and 19 recite a "degradable material" that degrades and forms voids in the proppant matrix. Degradable materials are described as "capable of undergoing an irreversible degradation downhole." '904 Patent, 7:18–19. And, the '904 patent goes on to explain that "irreversible" means that "the degradable material should not reform a solid or reconsolidate while downhole, e.g., the degradable material should degrade in situ but should not recrystallize or reconsolidate in situ." '904 Patent, 7:19–23.

76. This "irreversible" aspect of the term "degradable material" is generally consistent with how one skilled in the art would understand the degradation process. Moreover, the "irreversible" process is consistent with other descriptions in the '904 patent regarding degradation.

77. The '904 patent defines "degradable" or "degradation" to cover partial degradation by *any* mechanism, saying it refers "to at least the partial decomposition of the degradable material, and includes both homogenous and heterogeneous forms of degradation. This degradation can be the result of, for example, a chemical or thermal reaction, or a reaction induced by radiation." '904 Patent, 7:23–29.

78. Reading this, one skilled in the art would understand that the patent defines the term degradation broadly, covering partial and complete degradation

by *any* mechanism—there is no requirement that the material degrades, for example, upon exposure to water. Accordingly, one skilled in the art would understand that the broadest reasonable interpretation of "degradable material" is "any material capable of at least partially degrading downhole," where the degradation can be accomplished via any mechanism.

79. I note the patent also states that "suitable degradable materials . . . *should* be capable of undergoing an *irreversible degradation* downhole." '904 Patent, 7:18–19. Using the word *should* to modify irreversible degradation indicates that irreversibility is not a requirement of degradability *per se*, but an optional feature. And because the claims recite "degradable," not "irreversibly degradable," irreversibility is not a requirement of the claims under their broadest reasonable interpretation.

80. Moreover, the '904 patent also defines "irreversible" using the word "should" again:

> The term "irreversible," as used herein, means that the degradable material *should* not reform a solid or reconsolidate while downhole, *e.g.*, the degradable material *should* degrade in situ but *should* not recrystallize or reconsolidate in situ."

Ex. 1001, 7:19–23 (emphasis added).

81. Reading this definition, one skilled in the art would conclude that "irreversibly" degradable materials *might* recrystallize or reconsolidate under

certain conditions, but they are not expected to do so under at least some conditions in at least some particular wells.

82. Accordingly, a person of skill in the art would interpret "degradable material" as used in the '904 patent as "any material capable of capable of at least partially degrading downhole by any mechanism."

B. "proppant matrix"

83. All of the independent recite a "proppant matrix." According to the '904 patent, a "proppant matrix" is "a consolidation of proppant particulates within a fracture that may be adjacent to a well bore in a subterranean formation." '904 Patent, 3:24–27. This is generally consistent with how a person of skill in the art would understand the term "proppant matrix" as encompassing any closely-associated groups of proppant particles. Notably, this does not specify how the proppant is placed into the fracture or the type of proppant used.

84. Furthermore, the proppant matrix will be formed wherever the proppant is present in the fracture in sufficient quantities, which may be adjacent to the wellbore, but also includes along the newly-created fracture as the fractures are filled with proppant. Accordingly, I do not include the phrase "may be adjacent" in my construction. And as noted above, proppant matrixes were well-known in the art, and the '904 patent recognizes that proppant matrixes can be achieved by "conventional" technology. '904 patent, 1:37–46.

85. The ’904 patent describes that the proppant matrix can be formed specifically by resin coatings, tackifying agents, or interlocking particles. ’904 Patent, 3:27–33. And, as noted above, it was also well-known in the art to create proppant matrixes through using fiber-assisted proppant transport where the proppant forms stable packs or matrixes with the fiber without decreasing permeability or conductivity. *See, e.g.*, Palmer, 1:31–45. But, as would be known to a person of skill in the art, even an uncoated proppant particle can form an agglomeration or consolidation in a formation, resulting in a proppant matrix because of the closely-associated particles (*see, e.g.*, Huitt, 1:35–44; Watanabe, 1:30–36; Card, 1:37–45. The pressure applied by the fracture can create an agglomeration, as can Van der Waals or electrostatic forces. Moreover, I understand that particular dependent claims limit the proppant matrix further as including a curable resin, a tackifying agent, or interlocking proppant particles, among other things. Thus, the independent claims are necessarily broader, and do not require a proppant matrix comprising any of these types of proppant particles.

86. Accordingly, a person of skill in the art would interpret “proppant matrix” as used in the ’904 patent as “a consolidation of proppant particulates within a fracture in a subterranean formation.” Because this definition does not specify the method used to form the consolidation or the type of proppant particle

used, a person of ordinary skill in the art would understand that this definition covers all methods for forming the consolidation as well as any type of proppant particles.

VIII. Summary of Primary Prior Art References

87. I have been informed that the references in this section are prior art. I am not a patent lawyer and I do not hold myself out as an expert in determining whether a reference is prior art.

A. U.S. Patent No. 3,316,965 (Ex. 1008, "Watanabe")

88. Watanabe (filed in 1963 and issued in 1967) is, like the '904 patent, directed to treating and fracturing subterranean formations to stimulate oil and gas well production. Watanabe, 1:10–25. More specifically, Watanabe is directed to an improved proppant comprising a conventional proppant agent (such as sand) used in combination with a temporary or removable degradable particle that creates increased permeability when it is degraded.

89. Watanabe's removable degradable particles are hydrocarbon-polymer composite particles referred to as temporary propping agents. Watanabe, 3:67–4:19 (describing hydrocarbon-polymer particle and its degradation). The temporary propping agents can be used in combination with permanent propping agents such as sand. Watanabe, 3:45–50; 15:16–22 (describing conventional propping agents).

90. Watanabe's permanent propping agent forms a proppant matrix, *i.e.*, a consolidation of proppant, in the fracture. Watanabe, 14:43–50; *see also* 3:55–61. And, when the permanent propping agent is used in combination with a degradable temporary propping agent, Watanabe's hydrocarbon-polymer particles are removed, introducing a plurality of voids (*i.e.*, empty spaces) into the proppant matrix. Watanabe, 3:45–50 ("[a] still further object of this invention is to provide an improved temporary propping agent which, when used in combination with other permanent propping agents in fracturing operations, *can be dissolved away* leaving a maximum permeability in the propped fracture or fissure for formation oil flow") (emphasis added); *see also* 15:7–13.

B. U.S. Patent No. 6,328,105 (Ex. 1006, "Betzold")

91. Betzold (filed in 2000 and issued in 2001) is, like the '904 patent, directed to treating and fracturing subterranean formations to stimulate oil and gas well production. Betzold, 2:33–48. More specifically, Betzold is directed to an improved proppant comprising a conventional proppant agent (such as sand) used in combination with a temporary or removable degradable particle that creates increased permeability when it is degraded.

92. Betzold's removable degradable particles include degradable polymers or composite materials including additional components. Betzold, 3:42–4:48 (describing removable particles and their degradation). The removable

particles can be used in combination with conventional proppants (referred to as "bondable proppants" in Betzold), preferably coated with a substance to improve proppant-matrix formation. Betzold, 2:36–37 (mixture of bondable particles and removable particles); 3:3–41 (describing bondable particles).

93. Betzold's bondable particles form a proppant matrix, *i.e.*, a consolidation of proppant, in the fracture. Betzold, 2:37–40 (bondable particles adhere to one another to form a substantially permanent, self-supporting matrix); 2:56–63 (formation of an especially strong matrix). And, when the bondable particles are used in combination with the removable particles, Betzold's removable particles degrade, introducing a plurality of voids (*i.e.*, empty spaces) into the proppant matrix. Betzold, 2:44–48 ([a]s a result of this removal, the interstitial spaces in the matrix left behind increase in size, thereby achieving higher matrix porosity and hence higher conductivity in the fracture as a whole"); *see also* 4:58–65.

C. U.S. Patent No. 5,599,863 (Ex. 1010, "Palmer")

94. Palmer (filed in 1999 and issued in 2003) is, like the '904 patent, directed to treating and fracturing subterranean formations to stimulate oil and gas well production. Palmer, 1:10–12; 2:38–55. More specifically, Palmer discloses a fracturing fluid that can contain a conventional proppant agent

together with a multi-purpose degradable particulate that creates increased permeability when it is degraded.

95. Palmer's solid degradable particulates can be selected for their delayed reactivity and/or degradation characteristics, and may include mixtures of various well-known polymers including polyamides, polyesters, etc. Palmer, 3:66–4:49. According to Palmer, "the precise nature of the proppant employed is not critical." Palmer, 9:39–49 (describing numerous conventional proppants). Palmer teaches that the proppant composition, *i.e.*, the solid particulate and the proppant, can be included in a fracturing treatment fluid. Palmer, 2:56–66 ("…provided in a fracturing fluid").

96. Palmer's proppant forms a proppant matrix, *i.e.*, a consolidation of proppant, in the fracture. Palmer, 10:26–36 ("a matrix or pack of such and proppant…is left in the fracture."). Palmer also reiterates that it was well-known in the art to create proppant matrixes through using fiber-assisted proppant transport where the proppant forms stable packs or matrixes with the fiber without decreasing permeability or conductivity. *See, e.g.*, Palmer, 1:31–45; *see also* claims 4 and 11. And, when the degradable particulates are removed, it introduces a plurality of voids (*i.e.*, empty spaces) into the proppant matrix. Palmer teaches that the goal of fracturing in general is to provide "flow channels to facilitate production of the hydrocarbons to the wellbore." Palmer, 1:15–19.

And, as explained in Palmer, improved recovery is an ongoing goal when proppant matrixes are used. Palmer, 1:31–45. Palmer explains that decomposition of the solid degradable particulate matter removes it from the deposit, so that "a matrix or pack of such and proppant…is left in the fracture," resulting in increased conductivity. Palmer, 10:26–36.

IX. Claims 1–20 are Unpatentable Over Watanabe in combination with Betzold

97. I have been asked to consider Watanabe (Ex. 1008) and Betzold (Ex. 1006) with regard to claims 1–20 of the '904 patent. Specifically, I have been asked whether these references teach the limitations of the claims and whether a person of ordinary skill in the art would be inclined to combine the teachings of Watanabe with the disclosure in Betzold.

98. As detailed below, it is my opinion that Watanabe in view of Betzold discloses each of the limitations set forth in claims 1–20. And, it is also my opinion that one of ordinary skill in the art would have been motivated to combine these references and could do so with a reasonable expectation of success, for the reasons discussed below. As such, it is my opinion that claims 1–20 of the '904 patent would have been obvious over Watanabe in view of Betzold.

A. Motivation to Combine Watanabe and Betzold and Reasonable Expectation of Success

99. As explained in greater detail above in the summary of prior art section, Watanabe and Betzold are both directed to precisely the same subject matter: an improved proppant comprising a conventional proppant agent (such as sand) used in combination with a temporary or removable degradable particle that creates increased permeability when it is degraded.

100. Although Watanabe teaches forming a proppant matrix by consolidating proppant in a fracture, one skilled in the art would have been motivated to combine Watanabe's teachings with Betzold's teachings of an improved coated proppant. As Betzold explains, "conductivity of proppant-filled fractures continues to be a problem" and "[a] resin-coated proppant particle generally has a greater crush resistance than the core substrate material and can be used at greater depths or may be used at the same depth with increased relative conductivity." Betzold, 2:4–5; 1:38–41. Betzold's resin-coated particles "bond" together to form "a substantially permanent, self-supporting matrix that is interspersed with removable particles…to form an especially strong matrix" for enhanced fracture conductivity—and therefore better production. Betzold, 2:33–63.

101. Watanabe describes the conventional proppant and degradable particle as (i) a permanent propping agent (such as sand) used in combination

with (ii) a temporary propping agent (which is a hydrocarbon-polymer particle). Watanabe, 3:45–50 (two types of particles); 3:67–4:19 (describing hydrocarbon-polymer particle and its degradation). Betzold describes the conventional proppant and degradable particle as (i) bondable particles (such as resin-coated sand) used in combination with (ii) a removable particle (which can be any suitable dissolvable particle or degradable polymer). Betzold, abstract; 3:16–23 (describing resin coating); claim 19.

102. With regard to the first component, *i.e.*, the conventional proppant, both Watanabe and Betzold teach that proppant agents known in the art can be used. Watanabe, 15:16–22 ("Permanent propping materials which typically are used in combination with the hydrocarbon-polymer spheroid particles of this invention are strong hard solids which are chemically inert and resistant to solvent action and elevated downhole temperatures, preferred materials being solids such as ground nut shells, e.g., walnut shells, peach seeds, plastic, coarse sand, or the like."); Betzold, 3:3–41 ("Materials which can be used as the bondable particles in the inventive proppant can comprise any particulate material which will serve as a bondable proppant. Such materials are well known in the art…" and describing various bondable particles disclosed in prior art or commercially available).

103. One skilled in the art would recognize that Betzold's bondable particles could be used as Watanabe's permanent propping agent to obtain the benefits of the resin coating, including forming a strong matrix as explained in Betzold. Moreover, the benefits of resin-coated proppants were well-known in the art (as detailed in Betzold, 1:36–44; 2:33–63), and thus one skilled in the art would be motivated to use Betzold's resin-coated bondable particles in place of Watanabe's permanent propping agent to achieve these known advantages, namely, greater crush resistance, reducing fines generation, and forming a strong matrix—all of which help improve production by increasing conductivity. Betzold, 1:33–45. Furthermore, because Betzold describes specific commercially-available bondable particles, one skilled in the art would be motivated to use Betzold's bondable particles in Watanabe's composition for convenience.

104. Indeed, this would merely be a substitution of one known type of conventional propping agents for another known type of conventional propping agents. Because the properties and characteristics of various resin-coated proppants were well-known (especially commercially-available ones), one skilled in the art would be able to successfully implement Betzold's resin-coated proppants when practicing Watanabe. Betzold provides additional teaching guiding one skilled in the art towards picking a particular proppant. Betzold,

3:17–41 (detailing resin-coated proppants known in the art); 1:53–57 (explaining when sand and ceramic proppants are chosen for various pressures).)

105. Thus, one skilled in the art could and would have replaced Watanabe's permanent propping agent with Betzold's bondable particles, especially in view of the teachings of these references, which emphasize that these are essentially well-known, and even off-the-shelf, components with benefits known in the art, including an improved matrix, reduced fines, and greater crush resistance. And, Watanabe's permanent propping agents and Betzold's bondable particles both function to prop open the fracture. In other words, one skilled in the art would have been able to carry out this replacement with a reasonable expectation of success and would have obtained predictable results.

106. For ease of reference, the claims are divided into individual elements such as 1[a], 1[b], etc. below where appropriate.

B. Claim 1

Claim 1[a]: A method comprising:

107. It is my understanding that the preamble of a claim is generally not limiting. To the extent it is limiting, Watanabe describes methods of using its improved propping agent to enhance the permeability of a proppant matrix by injecting the particles into the desired position. Watanabe, 13:5–18 (describing

using the particles as temporary propping agents and mixing the particles with a carrier fluid and then using the resulting mixture in conventional fracturing operations). Thus, in my opinion Watanabe teaches or renders obvious "methods" as recited in the preamble.

> **Claim 1[b]**: **providing a proppant matrix composition, the proppant matrix composition comprising at least a plurality of proppant particulates and at least a plurality of composite particles;**

108. Watanabe teaches a proppant matrix composition in accordance with the '904 patent. Although Watanabe does not use the term "proppant matrix," it would be clear to one skilled in the art that Watanabe actually describes a proppant matrix composition as in the '904 patent because Watanabe teaches a composition comprising proppant particulates and temporary propping agents (which are composite particles), consistent with the components of the '904 patent's "proppant matrix composition." Watanabe, 3:45–50 ("A still further object of this invention is to provide an improved temporary propping agent which, when used in combination with other permanent propping agents in fracturing operations, can be dissolved away leaving a maximum permeability in the propped fracture or fissure for formation oil flow").

109. Watanabe's temporary propping agents (*i.e.*, the claimed composite particles) are hydrocarbon-polymer particles including a degradable material (*i.e.*, the polymer) and a hydrocarbon component, in addition to other additives and

materials, and thus are composite particles. *See, e.g.*, Watanabe, 3:67–72. The composition of these particles is discussed in greater detail below.

110. As would be understood by those skilled in the art, Watanabe's composite particles and proppant particulates result in a proppant matrix composition that forms a proppant matrix (as required by claim 1[d]) when placed and consolidated in the fracture:

> A still further advantage in fracturing in combination with sand or other permanent propping agents with these hydrocarbon-polymer spheroids is that, while the spheroids do not prevent the sand from being crushed when the pressure is first released on the fracture, the deformable characteristics of my hydrocarbon-polymer particles or spheroids tend to maintain the crushed pieces of sand closely packed together.

Watanabe, 14:43–50; *see also* 1:40–41, 3:45–55 (temporary propping agent will dissolve away leaving the permanent proppant in place); 3:55–61 (temporary propping agents "hold[] the sand closely together and in place, thus not losing the effectiveness of the permanent propping agent by crushing and shifting").

111. The pieces of sand "closely packed together" and the sand held "closely together" are descriptions of a consolidation of proppant within a fracture in a subterranean formation, consistent with the definition of "proppant

matrix" discussed above and disclosed in the '904 patent.[1] Thus, Watanabe teaches a proppant matrix composition.

112. Even if Watanabe is not considered to teach a "proppant matrix composition" and "proppant matrix" is interpreted to require a consolidating agent, it would have been obvious to one skilled in the art to use the resin-coated bondable particles of Betzold in place of Watanabe's permanent propping agent together with Watanabe's hydrocarbon-polymer particles. *See, e.g.*, Betzold, 2:37–40 ("the bondable particles, when in place in a subterranean formation, adhere to one another to form a substantially permanent, *self-supporting matrix* that is interspersed with removable particles"); 4:49–53 (same). Using Betzold's resin-coated particles (which would consolidate to form a proppant matrix as defined in the '904 patent, '904 Patent, 1:40–44) together with Watanabe's temporary propping agent would result in a proppant matrix composition.

113. One skilled in the art would have been motivated to use Betzold's resin-coated particles together with Watanabe's temporary propping agents, and could do so with a reasonable expectation of success, for the reasons discussed above in paragraphs 99–105.

[1] In the event that "proppant matrix" is construed more narrowly to require a consolidation of proppant that "may be adjacent to the wellbore," this is also taught by Watanabe because the proppant necessarily packs adjacent to the wellbore (and along the fracture) as the fractures are filled with proppant.

114. Additionally, the '904 patent specifically describes proppant matrixes as known in the prior art, and in particular, using a resin coating as one way to form a proppant matrix.

115. Thus, in my opinion Watanabe alone, as well as when combined with Betzold, teaches or renders obvious "providing a proppant matrix composition…comprising at least a plurality of proppant particulates and at least a plurality of composite particles."

Claim 1[c]: the composite particles comprising a degradable material and a filler material;

116. Watanabe's hydrocarbon-polymer particles, *i.e.*, composite particles, are a degradable material (*i.e.*, the polymer) capable of degrading downhole mixed with a filler material (*i.e.*, the hydrocarbon).

117. Watanabe describes several types of suitable polymers, including amides (nylon), phenolic resins, and polyethylene. Watanabe, 5:7–56. Watanabe also explains how a POSA could choose an appropriate polymer for a particular application or condition. Watanabe, 3:67–4:11; 12:5–15. Watanabe's polymers are a degradable material, as they are oil-soluble. *E.g.*, Watanabe, 12:5–9; 14:54–60. Notably, as would be understood by those skilled in the art, many of these polymeric compounds (such as ethylene/vinyl acetate copolymers) would be "irreversibly" degraded as defined in the '904 patent, meaning that, once

degraded, they would not recrystallize or reconsolidate while downhole. '904 Patent, 7:19–23.

118. As noted above, the filler material is simply another material included in the composite particle that can serve many purposes. The filler material, *i.e.*, the hydrocarbon component of Watanabe's particles, is any number of the organic compounds described in Watanabe, including light aliphatic hydrocarbons, oils, waxes, greases, and polycyclic hydrocarbons. Watanabe, 4:37–5:6. These hydrocarbon components of Watanabe's hydrocarbon-polymer particles are also intended to be degraded, as they are oil-soluble. *E.g.*, Watanabe, 12:5–9; 14:54–60. This is consistent with the '904 patent's teaching that the filler material can be degradable. '904 patent, 10:1–21.

119. Watanabe also teaches that other fillers may be combined with the degradable polymer. For example, Watanabe describes the benefits of coating the particles with finely divided coating solids, including calcium carbonate. Watanabe, 7:57–8:14. The '904 patent describes calcium carbonate as a suitable inert filler. '904 patent, 11:39–44.

120. Watanabe also teaches that other components, *i.e.*, fillers, can be added to the particles in order to impart some specific property. Watanabe, 16:8–14. This is consistent with the '904 patent's teaching that the filler can complement the degradable material. '904 patent, 9:36–67.

121. Accordingly, in my opinion the combination of Watanabe and Betzold teaches or renders obvious "composite particles comprising a degradable material and a filler material."

Claim 1[d]: **introducing the proppant matrix composition into a fracture in a subterranean formation so as to form a proppant matrix in the fracture; and**

122. According to the '904 patent, the proppant matrix forms by consolidating the proppant matrix composition within the fracture. '904 Patent, 3:21–24. Watanabe teaches introducing the proppant matrix composition into a fracture in a subterranean formation so as to form a proppant matrix in the fracture. Watanabe, 3:45–50 ("A still further object of this invention is to provide an improved temporary propping agent which, when used in combination with other permanent propping agents in fracturing operations, can be dissolved away leaving a maximum permeability in the propped fracture or fissure for formation oil flow"). Watanabe explicitly teaches that the proppant matrix composition would be introduced into a fracture in a subterranean formation. Watanabe, 12:54–58 ("Then a carrier fluid with a propping agent slurried therein, either containing a permanent prop alone or containing both permanent and temporary props, is used to place the suspended propping agent in the fracture"); *see also* 13:28–33.

123. Watanabe teaches that a proppant matrix is formed in the fracture:

> A still further advantage in fracturing in combination with sand or other permanent propping agents with these hydrocarbon-polymer spheroids is that, while the spheroids do not prevent the sand from being crushed when the pressure is first released on the fracture, the deformable characteristics of my hydrocarbon-polymer particles or spheroids tend to maintain the crushed pieces of sand closely packed together.

Watanabe, 14:43–50; *see also* 3:55–61 (temporary propping agents "hold[] the sand closely together and in place, thus not losing the effectiveness of the permanent propping agent by crushing and shifting").

124. As noted above, the pieces of sand "closely packed together" and the sand held "closely together" are descriptions of a consolidation of proppant within a fracture in a subterranean formation, consistent with the definition of "proppant matrix" discussed above and disclosed in the '904 patent. Thus, Watanabe teaches forming a proppant matrix in a fracture.

125. And, as also explained above, even if Watanabe is not considered to teach forming a proppant matrix, it would have been obvious to one skilled in the art to use the resin-coated bondable particles of Betzold in place of Watanabe's permanent propping agent together with Watanabe's hydrocarbon-polymer particles to form a stronger matrix. *See, e.g.*, Betzold, 2:37–40 ("the bondable particles, when in place in a subterranean formation, adhere to one another to form a substantially permanent, *self-supporting matrix* that is interspersed with

removable particles") (emphasis added); 4:49–53 (same). See also discussion in paragraphs 99–105.

126. Thus, in my opinion Watanabe in view of Betzold teaches or renders obvious "introducing the proppant matrix composition into a fracture in a subterranean formation so as to form a proppant matrix in the fracture."

Claim 1[e]: **allowing the degradable material of the composite particles to degrade so as to form at least one void in the proppant matrix.**

127. As is clear from the '904 patent, "allowing the degradable material of the composite particles to degrade so as to form at least one void in the proppant matrix" simply means allowing sufficient time to pass for the degradable material to degrade, resulting in empty spaces or voids where the degradable material once was. *See, e.g.*, '904 Patent, 7:29–33 ("After the requisite time period dictated by the characteristics of the particular degradable material utilized in the composite particles of this invention, voids are created in the proppant matrix").

128. Watanabe's hydrocarbon-polymer particles are intended to introduce a plurality of voids (*i.e.*, empty spaces) into the proppant matrix via degradation of the particles. Watanabe teaches "[a] still further object of this invention is to provide an improved temporary propping agent which, when used in combination with other permanent propping agents in fracturing operations, *can be dissolved*

away leaving a maximum permeability in the propped fracture or fissure for formation oil flow." Watanabe, 3:45–50 (emphasis added). And, Watanabe notes it is important to use an appropriate amount of temporary propping agent so that after removal, the remaining propping agent has sufficient strength to hold the fracture open to the maximum amount possible, *i.e.*, in view of the voids created. Watanabe, 15:7–13.

129. And, Betzold also teaches that its removable particles are intended to introduce a plurality of voids (*i.e.*, empty spaces) into the proppant matrix via degradation of the particles. Betzold, 2:40–47 ("The removable particles…can then be removed from the matrix…As a result of this removal, the interstitial spaces in the matrix left behind increase in size, thereby achieving higher matrix porosity and hence higher conductivity in the fracture as a whole.").

130. Accordingly, in my opinion Watanabe in view of Betzold teaches or renders obvious "allowing the degradable material of the composite particles to degrade so as to form at least one void in the proppant matrix."

C. Claim 2

Claim 2: The method of claim 1 wherein at least one of the proppant particulates comprises a component selected from the group consisting of: curable resins; tackifying agents; interlocking proppant particulates; epoxy resins; furan resins; phenolic resins; furfuryl aldehyde resins: furfuryl alcohol resins; non-aqueous tackifying agents; aqueous tackifying agents; silyl modified polyamides; natural sand; ground nut hulls; man-made proppant

particulates; bauxite; ceramics; polymeric particulates; low density particulates; and combinations thereof.

131. Watanabe teaches "[p]ermanent propping materials which typically are used in combination with the hydrocarbon-polymer spheroid particles of this invention are … ground nut shells, *e.g.*, walnut shells, peach seeds, plastic, coarse sand, or the like.") Watanabe, 15:16–22. Betzold also teaches that proppant particles are "commonly made of sand, glass, bauxite, ceramic, and shells." Betzold, 1:33–35.

132. Betzold teaches bondable proppants comprising a curable resin. Betzold, 3:17–29; *see also* 1:33–41. Betzold notes specific commercial substrates as examples of resin-coated bondable particles, including Super DC® and Optiprop®, both available from Santrol Corporation. These are well-known, commercially-available products where the curable resin is a phenolic resin.[2] One skilled in the art would have been motivated to use Betzold's resin-coated particles in Watanabe's composition, and could do so with a reasonable expectation of success, for the reasons discussed above in paragraphs 99–105.

133. Accordingly, it is my opinion that Watanabe in view of Betzold renders obvious numerous options recited in claim 2, including at least curable resins, phenolic resin, natural sand, ground nut hulls, bauxite, and ceramic.

[2] *See, e.g.*, Ex. 1009 at 9:20–21 (a patent filed in 2000 describing Optiprop® as a phenolic resin from Santrol, confirming my understanding).

D. Claim 3

Claim 3: The method of claim 1 wherein at least one of the composite particles has a physical shape of a platelet, shaving, fiber, flake, ribbon, rod, strip, spheroid, toroid, pellet, or tablet.

134. Watanabe teaches generally spheroid particles, but it also discloses that "other shaped particles are operable for any temporary propping service." Watanabe, 14:63–69. And, Watanabe notes conventional plugging or sealing particle shapes include "fiber-like." Watanabe, 12:25–29.

135. Accordingly, it is my opinion that Watanabe in view of Betzold renders obvious "wherein at least one of the composite particles has a physical shape of a platelet, shaving, fiber, flake, ribbon, rod, strip, spheroid, toroid, pellet, or tablet."

E. Claim 4

Claim 4: The method of claim 1 wherein at least one of the proppant particulates have sizes in the range of from about 4 to 100 U.S. mesh.

136. Watanabe teaches that permanent propping agents normally range in size from 4 to about 100 mesh, and the most commonly used proppant sizes range from 8–12 mesh or from 12–20 mesh. Watanabe, 15:33–35. *See also* Betzold, 1:33–35 (proppant particles range in size from about 6 to 200 mesh). The teachings in Watanabe and Betzold overlap substantially with the range recited in claim 4.

137. Accordingly, it is my opinion that Watanabe in view of Betzold renders obvious "wherein at least one of the proppant particulates have sizes in the range of from about 4 to 100 U.S. mesh."

F. Claim 5

Claim 5: The method of claim 1 wherein the proppant matrix composition comprises a component selected from the group consisting of: acid reactive materials; inert fillers; and combinations thereof.

138. As noted above, Watanabe specifically teaches composite particles including inert fillers. For example, Watanabe describes the benefits of coating the particles with finely divided coating solids, including calcium carbonate. Watanabe, 7:57–8:14. The '904 patent describes calcium carbonate as a suitable inert filler. '904 Patent, 11:39–44.

139. Accordingly, it is my opinion that Watanabe in view of Betzold renders obvious "wherein the proppant matrix composition comprises a component selected from the group consisting of: acid reactive materials; inert fillers; and combinations thereof."

G. Claim 6

Claim 6: The method of claim 1 wherein the composite particles are present in an amount of from about 0.1% to about 30% based on the weight of the proppant particulates in the proppant matrix composition.

140. Watanabe teaches that the temporary propping agent particles comprise "not more than half of the total number of propping agent particles."

Watanabe, 15:14–16. This does not give a precise recommended amount by weight, but would be routinely optimized by one skilled in the art, and could easily overlap the "0.1% to about 30% by weight" of claim 6.

141. Furthermore, Betzold suggests that the removable particles be used in a range of from about 10% to about 30% by volume. Betzold, 5:10–17. Although Betzold describes the amount by volume rather than by weight, based on the types of particles described in Betzold, 10% to about 30% by volume would overlap with the "0.1% to about 30% by weight" of claim 6.

142. To calculate an illustrative example, I used sand as the proppant particulate (Betzold, 1:33) and polyester (Betzold, 3:51) as the degradable particle. To work back to the weight percentages recited in the claim, I used the formula for density, which is: density = mass/volume. The densities of these materials can be obtained from readily available sources. For the density of sand, I used 2650 kg/m^3 the Handbook of Chemistry & Physics.[3] The grain density of sand (mostly quartz) is 2650 Kg/m^3. If you pack the sand loosely it has a bulk density of approximately 1600 Kg/m^3 (more if you compact it).

143. The density of polyester is about 1350 Kg/m^3. For the density of polyester, I used 1350 kg/m^3 from AZO Materials, an online publication directed

[3] David R. Lide, *Handbook of Chemistry & Physics* 15-32 (88th Ed. 2002).

to materials science.[4] While the density of the polyester removable particle would be slightly different if it was formulated as a composite rather than a pure polyester particle, I used the pure polyester value for illustrative purposes.

144. To calculate the values equivalent to the "10%" in the claim, I did the following calculation:

For a solid proppant volume of 1 m^3, a 10% by volume removable particles can be translated into a mass fraction as follows:

(0.1*1350) / (0.9*2650) = 0.0566 * 100 = 5.7%

So a 10% by volume mixture of degradable particles is equivalent to 5.7% by weight.

Similarly, a maximum ratio of 30% by volume removable particles can be translated into a weight fraction as follows:

(0.3*1350) / (0.7*2650) = 0.218 *100 = 21.8%

145. So, Betzold's teaching of using removable particles in a range of from about 10% to about 30% by volume corresponds to 5.7% to 21.8% by weight, largely overlapping with the range recited in the claim.

[4] https://www.azom.com/article.aspx?ArticleID=2047 (providing properties of polyethylene terephthalate, "the most common thermoplastic polyester…often called just "polyester.") This reference gave a density of 1.3 – 1.4 g/cm^3, which I averaged and converted to kg/m^3.

146. I also note that Betzold teaches that the preferred range is 10% to 20% by volume of removable particles. Betzold, 5:13–15. Carrying out the same calculation for the 20% value results in:

(0.2*1350) / (0.8*2650) = 274 / 2120 = 0.127 = 12.7% for a 20% volume.

Thus, Betzold's "preferred" range is 5.7% to 12.7% by weight, completely within the range recited in the claim.

147. Even if the values in Watanabe and Betzold do not overlap with the recitation of claim 6, one skilled in the art would have been motivated to choose an amount within this range. Notably, the '904 patent does not associate anything special with this concentration, and simply explains that the relative amounts should be chosen to avoid creating "an undesirable percentage of voids" rendering the proppant matrix ineffective to maintain the integrity of the fracture. '904 Patent, 11:55–12:3. Watanabe and Betzold both discuss precisely the same concern; namely, using an appropriate amount of degradable material so that the propping agent retains sufficient strength. Watanabe, 15:7–13; Betzold, 5:18–42. Thus, one skilled in the art would have been motivated to select an amount of composite particles from about 0.1% to about 30% based on the weight of the proppant particulates in the proppant matrix composition in order to maximize the number of voids while retaining sufficient strength in the matrix.

148. Moreover, the composite particles have the same function—degrading to create voids in the matrix—regardless of precise concentration, and a POSA would be able to optimize the concentration for a particular application using known techniques while successfully achieving voids in the matrix.

149. Accordingly, it is my opinion that Watanabe in view of Betzold teaches or renders obvious the limitation "wherein the composite particles are present in an amount of from about 0.1% to about 30% based on the weight of the proppant particulates in the proppant matrix composition."

H. Claim 7

Claim 7: The method of claim 1 wherein at least one of the composite particles comprises a material selected from the group consisting of: degradable polymers; aliphatic polyester homopolymers; random aliphatic polyester copolymers; block aliphatic polyester copolymers; star aliphatic polyester copolymers; hyperbranched aliphatic polyester copolymers; and combinations thereof.

150. Watanabe describes several types of suitable degradable polymers for use in its composite particles, including amides (nylon), phenolic resins, and polyethylene. Watanabe, 5:7–56; *see also* 12:5–12; 14:54–60.

151. Accordingly, it is my opinion that Watanabe in view of Betzold teaches or renders obvious the limitation of claim 7, which includes degradable polymers as one option.

I. Claim 8

Claim 8: The method of claim 1 wherein at least one of the composite particles comprises a material selected from the group consisting of: polysaccharides; chitins; chitosans; proteins; aliphatic polyesters; poly(lactides); poly(glycolides); poly(ε-caprolactones); poly(hydroxy ester ethers); poly(hydroxybutyrates); polyanhydrides; polycarbonates; poly(orthoesters); poly(acetals); poly(acrylates); poly(alkylacrylates); poly(amino acids); poly(ethylene oxides); poly ether esters; polyester amides; polyamides; polyphosphazenes; copolymers thereof; and blends thereof.

152. Watanabe teaches numerous types of degradable materials suitable for use in its composite particles, including polyester amides (Watanabe, 5:7–12, referring to nylon, which one skilled in the art would recognize to be a polyamide) and polyacrylates (Watanabe, 5:18–26, copolymers of ethylene and ethylacrylate or methylacrylate). These components could be incorporated into Watanabe's composite particles.

153. Accordingly, it is my opinion that Watanabe in view of Betzold teaches or renders obvious the limitation of claim 8, which recites aliphatic polyesters, poly(acrylates), and polyamides as options.

J. Claim 9

Claim 9: The method of claim 1 wherein the filler of at least one of the composite particle comprises a material selected from the group consisting of: anhydrous salts; glass; talc; calcium carbonate; mica; magnesium oxide; mineral fillers; barite; silica; ethylenediaminetetraacetic acid; oxidizers; breakers; sodium persulfate; magnesium peroxide; derivatives thereof; and combinations thereof.

154. As noted above, Watanabe specifically describes coating the particles with finely divided coating solids, including calcium carbonate, which would be a filler. Watanabe, 7:57–8:14.

155. Accordingly, it is my opinion that Watanabe in view of Betzold renders obvious the limitation of claim 9, which recites calcium carbonate as one option.

K. Claim 10

Claim 10: The method of claim 1 wherein at least one of the composite particles comprises a component selected from the group consisting of: anhydrous salts; glass; talc; calcium carbonate; mica, magnesium oxide, mineral fillers; barite; silica; ethylenediaminetetraacetic acid; oxidizers; breakers; sodium persulfate; magnesium peroxide; derivatives thereof; and combinations thereof.

156. This claim appears to overlap substantially with claim 9. Accordingly, *see* discussion of claim 9 above.

L. Claim 11

Claim 11: The method of claim 1 wherein the proppant matrix composition is blended and then transported to a drill site.

157. Watanabe teaches that the composite particles (*i.e.*, temporary propping agents) are mixed with permanent propping agents (*see e.g.*, Watanabe, 3:45–50), and then used at a drill site (*see id.*, referring to "fracturing operations"). Similarly, Example XIX describes a slug of oil containing blended proppant and composite particles injected into a fracture. Watanabe, 26:69–75.

But, Watanabe does not explicitly teach that the proppant matrix is blended and then transported to the drill site.

158. Regardless, as would be known to one skilled in the art, a conventional way of using a proppant matrix composition would be to blend the components and transport the blended composition to the drill site. Indeed, Watanabe specifically teaches that transport characteristics would be considered by those skilled in the art. Watanabe, 18:73–19:13 (noting that coated particles may be more suitable for transport); *see also* Example VIII (describing storage and transport). Accordingly, one skilled in the art would choose to blend the proppant matrix composition ahead of time—selecting particles with appropriate transport characteristics based on Watanabe—and then transport the proppant matrix composition to the drill site for use and would be motivated to do so for efficiency reasons because the composition would be ready to use on-site. Indeed, preparing fracturing fluids and compositions ahead of time and transporting them to the drill site is a common way of proceeding to those skilled in the art. Moreover, the '904 patent does not associate anything special with this process, and simply describes it as one way of blending and using the proppant matrix composition. '904 Patent, 11:45–54.

159. Accordingly, it is my opinion that Watanabe in view of Betzold renders obvious the limitation "wherein the proppant matrix composition is blended and then transported to a drill site."

M. Claim 12

Claim 12: The method of claim 1 wherein the proppant matrix composition is prepared and used on-the-fly at the drill site.

160. As noted above, Watanabe teaches that the composite particles (*i.e.*, temporary propping agents) are mixed with permanent propping agents (*see e.g.*, Watanabe, 3:45–50), and then used at a drill site (*see id.*, referring to "fracturing operations"). Similarly, Example XIX describes a slug of oil containing blended proppant and composite particles injected into a fracture. Watanabe, 26:69–75. But, Watanabe does not explicitly teach that the proppant matrix composition is prepared and used on-the-fly at the drill site.

161. As would be known to one skilled in the art, a conventional way of using the proppant matrix composition would be to blend the components at the drill site and use them on-the-fly. One skilled in the art may be motivated to choose this approach for convenience based on the composition of the composite particles (if the particles would not be suitable for storage together with the proppant, for example), or if the components were transported from different locations. Indeed, preparing fracturing fluids and compositions on the fly is a common way of proceeding to those skilled in the art. Moreover, the '904 patent

does not associate anything special with this process, and simply describes it as one way of blending and using the proppant matrix composition. '904 Patent, 11:45–54.

162. Accordingly, it is my opinion that Watanabe in view of Betzold renders obvious the limitation "wherein the proppant matrix composition is prepared and used on-the-fly at the drill site."

N. Claim 13

Claim 13: The method of claim 1 wherein the proppant matrix composition is a component of a fracturing treatment fluid.

163. Watanabe teaches that the proppant matrix composition is a component of a fracturing treatment fluid. Watanabe, 12:54–58 ("Then a carrier fluid with a propping agent slurried therein, either containing a permanent prop alone or containing both permanent and temporary props, is used to place the suspended propping agent in the fracture"); *see also* 13:28–33; *see also* 13:12–17 ("The hydrocarbon-polymer particles of this invention are conveniently mixed with a carrier fluid in the same manner as other propping agents, and the resulting mixture is then employed in conventional fracturing operations…"). Similarly, Example XIX describes a slug of oil containing blended proppant and composite particles injected into a fracture as a fracturing treatment fluid. Watanabe, 26:69–75.

164. Accordingly, it is my opinion that Watanabe in view of Betzold renders obvious the limitation "wherein the proppant matrix composition is a component of a fracturing treatment fluid."

O. Claim 14

Claim 14[a]: A method comprising:

165. *See* discussion of claim 1[a] above.

Claim 14[b]: providing a proppant matrix composition, the proppant matrix composition comprising at least a plurality of proppant particulates and at least a plurality of composite particles,

166. *See* discussion of claim 1[b] above.

Claim 14[c]: the composite particles comprising a degradable material and a filler material;

167. *See* discussion of claim 1[c] above.

Claim 14[d]: allowing the proppant matrix composition to form a proppant matrix;

168. According to the '904 patent, the proppant matrix forms by consolidation of the proppant matrix composition within the fracture. '904 Patent, 3:21–24. Watanabe teaches allowing the proppant matrix composition to form a proppant matrix:

> A still further advantage in fracturing in combination with sand or other permanent propping agents with these hydrocarbon-polymer spheroids is that, while the spheroids do not prevent the sand from being crushed when the pressure is first released on the fracture, the

> deformable characteristics of my hydrocarbon-polymer particles or spheroids tend to maintain the crushed pieces of sand closely packed together.

Watanabe, 14:43–50; *see also* 1:40–41, 3:45–55 (temporary propping agent will dissolve away leaving the permanent proppant in place); 3:55–61 (temporary propping agents "hold[] the sand closely together and in place, thus not losing the effectiveness of the permanent propping agent by crushing and shifting"); 12:43–57.

169. As explained above, the pieces of sand "closely packed together" and the sand held "closely together" are descriptions of a consolidation of proppant within a fracture in a subterranean formation, consistent with the definition of "proppant matrix" discussed above and disclosed in the '904 patent. Thus, Watanabe teaches allowing the proppant matrix composition to form a proppant matrix.

170. And, also as explained above, even if Watanabe is not considered to teach allowing the proppant matrix composition to form a proppant matrix, it would have been obvious to one skilled in the art to use the resin-coated bondable particles of Betzold in place of Watanabe's permanent propping agent (*see, e.g.*, Betzold, 3:16–23) together with Watanabe's hydrocarbon-polymer particles. One skilled in the art would have been motivated to use Betzold's resin-coated particles together with Watanabe's temporary propping agents, and could do so

with a reasonable expectation of success, for the reasons discussed above in paragraphs 99–105.

171. Thus, in my opinion Watanabe alone or in view of Betzold teaches or renders obvious "allowing the proppant matrix composition to form a proppant matrix." *See also* discussion of claim 1[d] above.

Claim 14[e]: allowing the degradable material of the composite particle to degrade so as to form a void in the proppant matrix; and

172. *See* discussion of claim 1[e] above.

Claim 14[f]: allowing a fluid to flow through the proppant matrix.

173. According to the '904 patent, allowing a fluid to flow through the proppant matrix refers to the enhanced conductivity related to creating voids in the matrix. *See, e.g.*, '904 Patent, 3:3–13. Watanabe explains that the purpose of using a temporary propping agent that degrades away leaving voids is to allow a fluid to flow more freely through the proppant matrix. Watanabe, 3:45–50 ("A still further object of this invention is to provide an improved temporary propping agent which, when used in combination with other permanent propping agents in fracturing operations, can be dissolved away leaving a maximum permeability in the propped fracture or fissure for formation oil flow"); 14:53–60 ("The temporary propping elements, i.e., the hydrocarbon-polymer particles, can be

removed readily from around the permanent propping agent particles by the flow of produced well crude…").

174. Betzold also notes that the purpose of the removable particles is to increase the size of the interstitial spaces left in the matrix, creating higher conductivity. Betzold, 4:58–65. Betzold also notes the importance of balancing the concentrations of bondable particles and removable particles to maintain sufficient strength of the matrix, *i.e.*, to create a desirable number of voids in the proppant matrix while maintaining sufficient strength, and that one skilled in the art can modify the number of voids appropriately, depending on the particular formation and relevant factors. Betzold, 5:18–42. One skilled in the art would have been motivated to use Betzold's resin-coated particles in Watanabe's composition, and could do so with a reasonable expectation of success, for the reasons discussed above in paragraphs 99–105.

175. Thus, in my opinion Watanabe in view of Betzold teaches or renders obvious "allowing a fluid to flow through the proppant matrix."

P. Claim 15

Claim 15: The method of claim 14 wherein at least one of the proppant particulates comprises a curable resin anchor [sic] a tackifying agent.

176. As is apparent from the file history, this claim includes a typo and "anchor" should be "and/or." Ex. 1020 at 18. Betzold teaches bondable

proppants comprising a curable resin. Betzold, 3:17–29; *see also* 1:33–41. One skilled in the art would have been motivated to use Betzold's resin-coated particles in Watanabe's composition, and could do so with a reasonable expectation of success, for the reasons discussed above in paragraphs 99–105.

177. Thus, in my opinion Watanabe in view of Betzold teaches or renders obvious a proppant matrix composition "wherein at least one of the proppant particulates comprises a curable resin [and/or] a tackifying agent."

Q. Claim 16

Claim 16: The method of claim 14 wherein the degradable material in at least one of the composite particles does not substantially degrade until after the proppant matrix has substantially formed.

178. Although Watanabe does not explicitly explain that the degradable material does not substantially degrade until after the proppant matrix has substantially formed, this would be understood by one skilled in the art. Specifically, given that the purpose of Watanabe is to create voids, it would be understood that the matrix should be substantially formed before the temporary propping agent degrades, as this process would result in voids. Watanabe, 3:45–50; 15:7–13.

179. Moreover, Betzold explicitly explains that the removable particles can be removed from the matrix "after formation of the matrix." Betzold, 2:35–47. One skilled in the art would have been motivated to use Betzold's resin-

coated particles in Watanabe's composition, and could do so with a reasonable expectation of success, for the reasons discussed above in paragraphs 99–105.

180. Thus, in my opinion Watanabe in view of Betzold teaches or renders obvious the limitation "wherein the degradable material in at least one of the composite particles does not substantially degrade until after the proppant matrix has substantially formed."

R. Claim 17

Claim 17: The method of claim 14 wherein at least one of the composite particles comprises a material selected from the group consisting of: polysaccharides; chitins; chitosans; proteins; aliphatic polyesters; poly(lactides); poly(glycolides); poly(ε-caprolactones); poly(hydroxy ester ethers); poly(hydroxybutyrates); polyanhydrides; polycarbonates; poly(orthoesters); poly(acetals); poly(acrylates); poly(alkylacrylates); poly(amino acids); poly(ethylene oxides); poly ether esters; polyester amides; polyamides; polyphosphazenes; copolymers thereof; and blends thereof.

181. *See* discussion of claim 8 above.

S. Claim 18

Claim 18: The method of claim 14 wherein the filler of at least one of the composite particle comprises a component selected from the group consisting of: anhydrous salts; glass; talc; calcium carbonate; mica, magnesium oxide, mineral fillers; barite; silica; ethylenediaminetetraacetic acid; oxidizers; breakers; sodium persulfate; magnesium peroxide; derivatives thereof; and combinations thereof.

182. *See* discussion of claim 9 above.

T. Claim 19

Claim 19[a]: A method comprising:

183. *See* discussion of claim 1[a] above.

Claim 19[b]: providing a treatment fluid that comprises a proppant matrix composition, the proppant matrix composition comprising at least a plurality of proppant particulates and at least a plurality of composite particles,

184. *See* discussion of claim 1[b] above. Although claim 1[b] does not specifically address providing the proppant matrix composition *in a treatment fluid*, Watanabe teaches that the proppant matrix composition is a component of a fracturing treatment fluid. Watanabe, 12:54–58 ("Then a carrier fluid with a propping agent slurried therein, either containing a permanent prop alone or containing both permanent and temporary props, is used to place the suspended propping agent in the fracture"); *see also* 13:28–33; *see also* 13:12–17 ("The hydrocarbon-polymer particles of this invention are conveniently mixed with a carrier fluid in the same manner as other propping agents, and the resulting mixture is then employed in conventional fracturing operations…"). Similarly, Example XIX describes a slug of oil containing blended proppant and composite particles injected into a fracture as a fracturing treatment fluid. Watanabe, 26:69–75.

185. Thus, in my opinion Watanabe in view of Betzold teaches or renders obvious the limitation "providing a treatment fluid that comprises a proppant

matrix composition, the proppant matrix composition comprising at least a plurality of proppant particulates and at least a plurality of composite particles."

Claim 19[c]: the composite particles comprising a degradable material and a filler material;

186. *See* discussion of claim 1[c] above.

Claim 19[d]: contacting at least a portion of a subterranean formation with the treatment fluid under conditions effective to create or enhance at least one fracture in the subterranean formation; and

187. Watanabe describes using the treatment fluid comprising the composite particle and proppant in fracturing operations, *i.e.*, under conditions effective to create or enhance at least one fracture in the subterranean formation. Watanabe, 3:45–50 ("A still further object of this invention is to provide an improved temporary propping agent which, when used in combination with other permanent propping agents in fracturing operations, can be dissolved away leaving a maximum permeability in the propped fracture or fissure for formation oil flow"); 12:54–58 ("Then a carrier fluid with a propping agent slurried therein, either containing a permanent prop alone or containing both permanent and temporary props, is used to place the suspended propping agent in the fracture"); *see also* 13:28–33; *see also* 13:12–17 ("The hydrocarbon-polymer particles of this invention are conveniently mixed with a carrier fluid in the same manner as other propping agents, and the resulting mixture is then employed in conventional

fracturing operations…"). Similarly, Example XIX describes a slug of oil containing blended proppant and composite particles injected into a fracture as a fracturing treatment fluid. Watanabe, 26:69–75.

188. Accordingly, in my opinion, Watanabe in view of Betzold teaches or renders obvious the limitation "contacting at least a portion of a subterranean formation with the treatment fluid under conditions effective to create or enhance at least one fracture in the subterranean formation."

Claim 19[e]: allowing the proppant matrix composition to form a proppant matrix having at least one void therein.

189. *See* discussion of claim 14[d] (with regard to allowing the proppant matrix composition to form a proppant matrix) and claim 1[e] (with regard to forming at least one void in the proppant matrix) above.

U. Claim 20

Claim 20: The method of claim 19 wherein at least one of the composite particles comprises a material selected from the group consisting of: polysaccharides; chitins; chitosans; proteins; aliphatic polyesters; poly(lactides); poly(glycolides); poly(ε-caprolactones); poly(hydroxy ester ethers); poly(hydroxybutyrates); polyanhydrides; polycarbonates; poly(orthoesters); poly(acetals); poly(acrylates); poly(alkylacrylates); poly(amino acids); poly(ethylene oxides); poly ether esters; polyester amides; polyamides; polyphosphazenes; copolymers thereof; and blends thereof.

190. *See* discussion of claim 8 above.

X. Claims 1–20 are Unpatentable Over Palmer

191. I have been asked to consider Palmer (Ex. 1010) with regard to claims 1–20 of the '904 patent. Specifically, I have been asked whether this reference teaches the limitations of the claims and whether a person of ordinary skill in the art would understand the claims to be obvious based on the disclosure of Palmer.

192. As explained in greater detail above in the summary of prior art section, Palmer is directed to a multi-purpose degradable particulate used in fracturing fluids. The particulate includes a degradable polymer that acts as a breaker material and can also improve proppant transport. Palmer, 2:48–55. Palmer explicitly teaches that "composite particles" including various natural and synthetic materials may be employed as its degradable particulates. Palmer, 4:49–59.

193. Palmer teaches that the goal of fracturing in general is to provide "flow channels to facilitate production of the hydrocarbons to the wellbore." Palmer, 1:15–19. And, as explained in Palmer, improved recovery is an ongoing goal when proppant matrixes are used. Palmer, 1:31–45. Breaking a gel is necessary to allow hydrocarbon flow through the fracture and proppant matrix. Palmer, 2:3–10. Palmer teaches using a degradable particulate material as an improved breaker, where the particulate's degradation removes the particulates

and simultaneously breaks the gel, leaving the matrix behind. Palmer, 10:26–36. Accordingly, the particulate's removal creates a desirable number of voids in the proppant matrix.

194. As detailed below, it is my opinion that Palmer discloses each of the limitations set forth in claims 1–20. In a few instances, Palmer's disclosure may not use the same terminology as the claim limitation, but I have explained why the limitation would have been understood by one skilled in the art to be disclosed by Palmer and thus obvious thereover. As such, it is my opinion that claims 1–20 of the '904 patent would have been obvious over Palmer.

195. For ease of reference, the claims are divided into individual elements such as 1[a], 1[b], etc. below where appropriate.

A. Claim 1

Claim 1[a]: A method comprising:

196. It is my understanding that the preamble of a claim is generally not limiting. To the extent it is limiting, Palmer describes methods of using its degradable particulates to enhance the permeability of a proppant matrix. Palmer, 10:8–36. Thus, in my opinion, Palmer teaches or renders obvious "methods" as recited in the preamble.

> **Claim 1[b]**: **providing a proppant matrix composition, the proppant matrix composition comprising at least a plurality of proppant particulates and at least a plurality of composite particles;**

197. Palmer teaches a proppant matrix composition in accordance with the '904 patent. Specifically, Palmer teaches enhancing the permeability of a proppant matrix using a solid degradable particulate in combination with a proppant, explaining that decomposition of the solid degradable particulate matter removes it from the deposit, so that "a matrix or pack of such and proppant…is left in the fracture." Palmer, 10:26–36. Palmer also teaches forming matrixes with fibers. Palmer, 1:31–45; *see also* claims 4 and 11.

198. Palmer also explains that the composition can include at least a plurality of proppant particulates and at least a plurality of solid particulates. Palmer, 2:56–66 (solid particulates provided in a fracturing fluid with proppant and gellant); 6:19–23; 9:61–65; 9:39–59 (various proppants).

199. Palmer's solid degradable particulates can be composite particles selected for their delayed reactivity and/or degradation characteristics, and may include mixtures of various well-known polymers including polyamides, polyesters, etc. Palmer, 3:66–4:49. Palmer explicitly teaches that "composite particles" including various natural and synthetic materials may be employed. Palmer, 4:49–59.

200. Thus, Palmer teaches or renders obvious "providing a proppant matrix composition…comprising at least a plurality of proppant particulates and at least a plurality of composite particles."

Claim 1[c]: **the composite particles comprising a degradable material and a filler material;**

201. Palmer's particulates are selected for their delayed reactivity and/or degradation characteristics, and may include mixtures of various well-known degradable polymers including polyamides, polyesters, etc. Palmer, 3:66–4:49. Regardless of the composition, Palmer's particulates are intended to degrade or decompose in a downhole environment, effectively removing the particulate matter while the degradation products effectively break the gel. Palmer, 3:8–28.

202. As noted above, the filler material is simply another material included in the composite particle that can serve many purposes. Palmer teaches that the particulate can be a composite of two degradable materials, with a core and a sheath having different degradation times. Palmer, 4:49–54. In that instance, one component would be considered the degradable material and the other component would be considered the filler material. This is consistent with the '904 patent's teaching that the filler material can be degradable. '904 patent, 10:1–21. Notably, as would be understood by those skilled in the art, many of these polymeric compounds (such as polyamides, polyesters and co-polymers of these) would be "irreversibly" degraded as defined in the '904 patent, meaning that, once degraded, they would not recrystallize or reconsolidate while downhole. '904 Patent, 7:19–23.

203. Palmer's particulates can also include other types of filler materials such as commercially available additives, fillers, or coatings, as long as these additional components do not interfere with the required activity. Palmer, 4:51–59.

204. Accordingly, Palmer teaches or renders obvious **"**composite particles comprising a degradable material and a filler material."

Claim 1[d]: **introducing the proppant matrix composition into a fracture in a subterranean formation so as to form a proppant matrix in the fracture; and**

205. According to the '904 patent, the proppant matrix forms by consolidation of the proppant matrix composition within the fracture. '904 Patent, 3:21–24. Palmer teaches introducing the proppant matrix composition into a fracture in a subterranean formation so as to form a proppant matrix in the fracture. Palmer explains that the solid particulate is provided in a fracturing fluid with a gellant and proppant, forming a fracturing fluid suspension, and this suspension is pumped downwell and deposited as a gelled suspension in the subterranean formation under fracturing conditions. Palmer, 2:56–66.

206. Once downwell, this composition forms a proppant matrix. Palmer, 10:26–36 (explaining that "a matrix or pack of such and proppant…is left in the fracture"); *see also* 1:33–42 (describing forming proppant matrixes in general and

benefits thereof). Palmer's teachings are consistent with the definition of "proppant matrix" discussed above and disclosed in the '904 patent.[5]

207. Thus, Palmer teaches or renders obvious "introducing the proppant matrix composition into a fracture in a subterranean formation so as to form a proppant matrix in the fracture."

Claim 1[e]: **allowing the degradable material of the composite particles to degrade so as to form at least one void in the proppant matrix.**

208. As is clear from the '904 patent, "allowing the degradable material of the composite particles to degrade so as to form at least one void in the proppant matrix" simply means allowing sufficient time to pass for the degradable material to degrade, resulting in empty spaces or voids where the degradable material once was. *See, e.g.*, '904 Patent, 7:29–33 ("After the requisite time period dictated by the characteristics of the particular degradable material utilized in the composite particles of this invention, voids are created in the proppant matrix").

209. Palmer explains that the purpose of degrading the solid particulates is to help break the gel in the fracture in order to accomplish flow through the fracture and proppant pack, *i.e.*, matrix. Palmer, 2:3–10. Although Palmer may

[5] In the event that "proppant matrix" is construed more narrowly to require a consolidation of proppant that "may be adjacent to the wellbore," this is also taught by Palmer because the proppant necessarily packs adjacent to the wellbore (and along the fracture) as the fractures are filled with proppant.

not explicitly teach that degradation of its particulates results in "form[ing] at least one void in the proppant matrix," this would have been obvious to one skilled in the art upon reading Palmer. Palmer explains that decomposition of the solid degradable particulate matter removes it from the deposit, so that "a matrix or pack of such and proppant…is left in the fracture." Palmer, 10:26–36. Removing the solid particulate while leaving the proppant behind would be understood to introduce voids into the proppant matrix. My opinion is supported by the fact that Palmer also explains that the purpose of degrading the solid particulates is to help improve flow through the fracture and proppant pack, *i.e.*, matrix, which would be accomplished through the voids. Palmer, 2:3–10.

210. Accordingly, Palmer teaches "allowing the degradable material of the composite particles to degrade so as to form at least one void in the proppant matrix."

B. Claim 2

Claim 2: The method of claim 1 wherein at least one of the proppant particulates comprises a component selected from the group consisting of: curable resins; tackifying agents; interlocking proppant particulates; epoxy resins; furan resins; phenolic resins; furfuryl aldehyde resins: furfuryl alcohol resins; non-aqueous tackifying agents; aqueous tackifying agents; silyl modified polyamides; natural sand; ground nut hulls; man-made proppant particulates; bauxite; ceramics; polymeric particulates; low density particulates; and combinations thereof.

211. Palmer teaches that "the precise nature of the proppant employed is not critical," and describes numerous conventional proppants including resin-coated sand or ceramic proppant and bauxite. Palmer, 9:39–60.

212. Accordingly, it is my opinion that Palmer teaches or renders obvious numerous options recited in claim 2, including at least curable resins, natural sand, bauxite, and ceramic.

C. Claim 3

Claim 3: The method of claim 1 wherein at least one of the composite particles has a physical shape of a platelet, shaving, fiber, flake, ribbon, rod, strip, spheroid, toroid, pellet, or tablet.

213. Palmer teaches that the particulates can be used "in all possible shapes," specifically mentioning fibers and platelets. Palmer, 3:1–2. And, Palmer describes straight fibers having a round cross-section as a suitable example. Palmer, 5:40–41. One skilled in the art would recognize these fibers as particles having a rod-like shape.

214. Accordingly, it is my opinion that Palmer teaches or renders obvious "wherein at least one of the composite particles has a physical shape of a platelet, shaving, fiber, flake, ribbon, rod, strip, spheroid, toroid, pellet, or tablet."

D. Claim 4

Claim 4: The method of claim 1 wherein at least one of the proppant particulates have sizes in the range of from about 4 to 100 U.S. mesh.

215. Palmer teaches that normally the proppant will have an average article size less than about 8 mesh and greater than 60 or 80 mesh, or sized mixtures may be used. Palmer, 9:52–58. This overlaps substantially with the range recited in claim 4.

216. Accordingly, it is my opinion that Palmer teaches or renders obvious "wherein at least one of the proppant particulates have sizes in the range of from about 4 to 100 U.S. mesh."

E. Claim 5

Claim 5: The method of claim 1 wherein the proppant matrix composition comprises a component selected from the group consisting of: acid reactive materials; inert fillers; and combinations thereof.

217. As noted above, Palmer's particulates can include filler materials such as commercially available additives, fillers, or coatings, as long as these additional components do not interfere with the required activity. Palmer, 4:51–59. As one skilled in the art would recognize, if a component does not interfere with the required activity, it would be considered an inert filler.

218. Accordingly, it is my opinion that Palmer teaches or renders obvious "wherein the proppant matrix composition comprises a component selected from the group consisting of: acid reactive materials; inert fillers; and combinations thereof."

F. Claim 6

Claim 6: The method of claim 1 wherein the composite particles are present in an amount of from about 0.1% to about 30% based on the weight of the proppant particulates in the proppant matrix composition.

219. Palmer teaches that the amount of particulate used is up to 10% of the fluid by weight. Palmer, 5:1–6. And, the proppant is suggested to be added in a concentration of from 0.5 or 1 lb/gallon to about 25 lb/gallon. Palmer, 9:49–52. This does not give a precise recommended amount by weight, but would be routinely optimized by one skilled in the art, and overlaps the "0.1% to about 30% by weight" of claim 6.

220. Palmer refers to the amount of particulate as ranging from 0.02 % up to about 10% by weight of the fluid. Palmer, 5:1–6. To calculate an illustrative example, I used water as the fracturing fluid.

221. A gallon of water weighs 8.34 pounds. So, at the low end, 0.02% particulate by weight = 0.001668 pounds of degradable material per gallon. At the high end, 10% particulate by weight = 0.834 pounds of degradable material per gallon.

222. Palmer teaches that the proppant is used in a concentration of from 0.5 or 1 lb/gallon up to about 25 lbs/gallon. Palmer, 9:49–51.

223. Accordingly, the lowest ratio of degradable material to proppant is 0.001668/25 = 0.000067. The highest ratio of degradable material to proppant is

0.834/0.5 = 1.67. This equates to a range of 0.0067% to 167% by weight, overlapping with the range recited in the claim.

224. Although there may be slight variances in weights of water-based fracturing fluids resulting in slightly different values, the calculations should still result in overlap for these materials.

225. It is possible that Palmer refers to the total weight, *i.e.*, including the degradable material, when it refers to the weight of the fluid. In that case, the calculation would be slightly different. In short:

Weight of fracturing fluid = weight of degradable material + weight of water, or in shorthand, Wf = Wd + Ww (or in other words, Wd = Wf – Ww).

226. For the minimum range, Wd = 0.0002(Wf).

$$Wd = Wf - Ww$$
$$0.0002(Wf) = Wf - Ww$$
$$Wf(.0002-1) = -Ww$$
$$Wf(-.9998) - 8.34 \text{ lb/gal}$$
$$Wf = 8.34167 \text{ lb/gal}$$

227. Putting that back in to the above equation: Wf = Wd + Ww, the result is 8.34167 = Wd + 8.34. So, Wd = 0.00167 lb/gal. Thus the minimum ratio is (0.00167/25 lb/gal) = 0.00668%. Doing the same calculation steps for the maximum ratio (10% degradable material by weight to .5 lb/gal of proppant) yields a 186% max ratio.

228. Accordingly, even if fluid by weight is construed this way, it equates to a range of 0.00668% to 186% by weight, again overlapping with the range recited in the claim.

229. Even if the values in Palmer do not overlap with the recitation of claim 6, one skilled in the art would have been motivated to choose an amount within this range to maximize the number of voids while retaining sufficient strength in the matrix. Notably, the '904 patent does not associate anything special with this concentration, and simply explains that the relative amounts should be chosen to avoid creating "an undesirable percentage of voids" rendering the proppant matrix ineffective to maintain the integrity of the fracture. '904 Patent, 11:55–12:3. One skilled in the art would have precisely the same concern, and would have been motivated to select an amount of composite particles from about 0.1% to about 30% based on the weight of the proppant particulates in the proppant matrix composition in order to maximize the number of voids while retaining sufficient strength in the matrix..

230. Moreover, the composite particulates have the same function—degrading to create voids in the matrix—regardless of precise concentration, and a POSA would be able to optimize the concentration for a particular application using known techniques while successfully achieving voids in the matrix.

231. Accordingly, it is my opinion that Palmer teaches or renders obvious the limitation "wherein the composite particles are present in an amount of from about 0.1% to about 30% based on the weight of the proppant particulates in the proppant matrix composition."

G. Claim 7

Claim 7: The method of claim 1 wherein at least one of the composite particles comprises a material selected from the group consisting of: degradable polymers; aliphatic polyester homopolymers; random aliphatic polyester copolymers; block aliphatic polyester copolymers; star aliphatic polyester copolymers; hyperbranched aliphatic polyester copolymers; and combinations thereof.

232. Palmer describes several types of suitable degradable polymers for use in its composite particles. *E.g.*, Palmer, 3:66–4:59 (describing particulates and their degradation). Thus, Palmer teaches a composite particle comprising a degradable polymer.

233. Accordingly, it is my opinion that Palmer teaches or renders obvious the limitation of claim 7, which recites degradable polymers as one option.

H. Claim 8

Claim 8: The method of claim 1 wherein at least one of the composite particles comprises a material selected from the group consisting of: polysaccharides; chitins; chitosans; proteins; aliphatic polyesters; poly(lactides); poly(glycolides); poly(ε-caprolactones); poly(hydroxy ester ethers); poly(hydroxybutyrates); polyanhydrides; polycarbonates; poly(orthoesters); poly(acetals); poly(acrylates); poly(alkylacrylates); poly(amino acids); poly(ethylene oxides);

poly ether esters; polyester amides; polyamides; polyphosphazenes; copolymers thereof; and blends thereof.

234. Palmer teaches examples of degradable polymers including cellulose, *i.e.*, a polysaccharide (Palmer, 4:37) and polyesters (Palmer, 4:39) in its particulates. As is known to those skilled in the art, many polyester polymers are aliphatic polyesters.

235. Accordingly, it is my opinion that Palmer teaches or renders obvious the limitation of claim 8, which recites both polysaccharides and aliphatic polyesters as options.

I. Claim 9

Claim 9: The method of claim 1 wherein the filler of at least one of the composite particle comprises a material selected from the group consisting of: anhydrous salts; glass; talc; calcium carbonate; mica; magnesium oxide; mineral fillers; barite; silica; ethylenediaminetetraacetic acid; oxidizers; breakers; sodium persulfate; magnesium peroxide; derivatives thereof; and combinations thereof.

236. Palmer's solid particulates are intended to function as breakers. Palmer, 3:66–4:2 (describing gel-breaking action of the particulates). Thus, in some instances, Palmer's filler material will be a breaker.

237. And, it would have been obvious to one skilled in the art to include a filler consisting of an anhydrous salt cross-linker based on Palmer. Palmer teaches using cross-linking agents including several types of anhydrous salts. Palmer, 9:9–22. Given that Palmer specifically teaches the benefits of a breaker

compound (*i.e.*, Palmer's particulate) having more than one function (Palmer, 2:24–32), it would have been obvious for one skilled in the art to add an anhydrous salt to the degradable polymer particulate so that it would function as both a cross-linker and a breaker. This is particularly true in view of the fact that Palmer teaches that composite materials are desirable, and can include a particle with a core and sheath structure where the core and sheath degrade over different periods of times. Palmer, 4:49–54. Accordingly, one skilled in the art would understand that the sheath could include an anhydrous salt, degrading downhole whereby the degradation products create a cross-linked gel at the appropriate location to transport proppant while still allowing sufficient fluidity for pumping (Palmer, 1:59–2:10 (describing delayed crosslinking and subsequent gel breaking); 7:59–8:5), and then the core could degrade later, breaking the gel created by the anhydrous salt at an appropriate time. Thus, one skilled in the art would have been motivated to use Palmer's anhydrous salts as a filler material.

238. Given the detailed disclosure of Palmer and the established practice of using anhydrous salt cross-linkers, gelled fluids, and breakers, one skilled in the art would have been able to make this modification with a reasonable expectation of success.

239. Accordingly, it is my opinion that Palmer teaches or renders obvious the limitation of claim 9, which recites breakers and anhydrous salts as options.

J. Claim 10

Claim 10: The method of claim 1 wherein at least one of the composite particles comprises a component selected from the group consisting of: anhydrous salts; glass; talc; calcium carbonate; mica, magnesium oxide, mineral fillers; barite; silica; ethylenediaminetetraacetic acid; oxidizers; breakers; sodium persulfate; magnesium peroxide; derivatives thereof; and combinations thereof.

240. This claim appears to overlap substantially with claim 9. Accordingly, *see* discussion of claim 9 above.

K. Claim 11

Claim 11: The method of claim 1 wherein the proppant matrix composition is blended and then transported to a drill site.

241. As would be known to one skilled in the art, a conventional way of using the proppant matrix composition would be to blend the components and transport the blended composition to the drill site. Indeed, Palmer specifically teaches that the suspensions may be blended offsite (and thus later transported to the drill site). Palmer, 7:1–2.

242. Moreover, the ’904 patent does not does not associate anything special with this process, and simply describes it as one way of blending and using the proppant matrix composition. ’904 Patent, 11:45–54.

243. Accordingly, it is my opinion that Palmer teaches or renders obvious “wherein the proppant matrix composition is blended and then transported to a drill site.”

L. Claim 12

Claim 12: The method of claim 1 wherein the proppant matrix composition is prepared and used on-the-fly at the drill site.

244. As would be known to one skilled in the art, a conventional way of using the proppant matrix composition would be to blend the components on-the-fly at the drill site. Indeed, Palmer specifically teaches that the suspensions may be blended on the fly. Palmer, 6:65–7:1.

245. Moreover, the '904 patent does not does not associate anything special with this process, and simply describes it as one way of blending and using the proppant matrix composition. '904 Patent, 11:45–54.

246. Accordingly, it is my opinion that Palmer teaches or renders obvious "wherein the proppant matrix composition is prepared and used on-the-fly at the drill site."

M. Claim 13

Claim 13: The method of claim 1 wherein the proppant matrix composition is a component of a fracturing treatment fluid.

247. Palmer teaches that the proppant matrix composition, *i.e.*, the solid particulate and the proppant, can be included in a fracturing fluid. Palmer, 2:56–66 ("…provided in a fracturing fluid").

248. Accordingly, it is my opinion that Palmer teaches or renders obvious "wherein the proppant matrix composition is a component of a fracturing treatment fluid."

N. Claim 14

Claim 14[a]: A method comprising:

249. *See* discussion of claim 1[a] above.

Claim 14[b]: providing a proppant matrix composition, the proppant matrix composition comprising at least a plurality of proppant particulates and at least a plurality of composite particles,

250. *See* discussion of claim 1[b] above.

Claim 14[c]: the composite particles comprising a degradable material and a filler material;

251. *See* discussion of claim 1[c] above.

Claim 14[d]: allowing the proppant matrix composition to form a proppant matrix;

252. According to the '904 patent, the proppant matrix forms by consolidating the proppant matrix composition within the fracture. '904 Patent, 3:21–24. Palmer teaches allowing the proppant matrix composition to form a proppant matrix. Palmer teaches enhancing the permeability of a proppant matrix using a solid degradable particulate in combination with a proppant, explaining that decomposition of the solid degradable particulate matter removes it from the deposit, so that "a matrix or pack of such and proppant…is left in the fracture." Palmer, 10:26–36. Palmer also teaches forming matrixes with fibers. Palmer, 1:31–45; *see also* claims 4 and 11.

253. Thus, Palmer teaches or renders obvious "allowing the proppant matrix composition to form a proppant matrix." *See also* discussion of claim 1[d] above.

Claim 14[e]: allowing the degradable material of the composite particle to degrade so as to form a void in the proppant matrix; and

254. *See* discussion of claim 1[e] above.

Claim 14[f]: allowing a fluid to flow through the proppant matrix.

255. According to the '904 patent, allowing a fluid to flow through the proppant matrix refers to the enhanced conductivity related to creating voids in the matrix. *See, e.g.*, '904 Patent, 3:3–13. Palmer teaches that the goal of fracturing in general is to provide "flow channels to facilitate production of the hydrocarbons to the wellbore." Palmer, 1:15–19. Improved recovery is an ongoing goal when proppant matrixes are used. Palmer, 1:31–45. Breaking a gel is necessary to allow hydrocarbon flow through the fracture and proppant matrix. Palmer, 2:3–10. And, Palmer teaches using a degradable particulate material as an improved breaker, where the particulate's degradation removes the particulates and simultaneously breaks the gel, leaving the matrix behind. Palmer, 10:26–36. The amount of particulate used is up to 10% of the fluid by weight, which one skilled in the art would understand to be an amount sufficient

to allow a fluid to flow through the proppant matrix in view of the other discussion in Palmer described. Palmer, 5:1–6.

256. Accordingly, it is my opinion that Palmer teaches or renders obvious "allowing a fluid to flow through the proppant matrix."

O. Claim 15

Claim 15: The method of claim 14 wherein at least one of the proppant particulates comprises a curable resin anchor [sic] a tackifying agent.

257. As is apparent from the file history, this claim includes a typo and "anchor" should be "and/or." Ex. 1020 at 18. Palmer teaches that resin-coated sand or ceramic proppant may be used. Palmer, 9:9:46–47. As would be understood by those skilled in the art, most resin used as proppant coating is curable resin. One skilled in the art would be motivated to use a well-established product such as curable resin because its performance characteristics were well-known in the art.

258. Thus, in my opinion Palmer teaches or renders obvious a proppant matrix composition wherein at least one of the proppant particulates comprises a curable resin and/or a tackifying agent.

P. Claim 16

Claim 16: The method of claim 14 wherein the degradable material in at least one of the composite particles does not substantially degrade until after the proppant matrix has substantially formed.

259. Although Palmer does not explicitly explain that the degradable material does not substantially degrade until after the proppant matrix has substantially formed, this would be understood by one skilled in the art because Palmer describes that the matrix is left behind after degradation. Palmer, 10:26-36 ("the decomposition or reaction of the solid particulate matter in effect 'removing' organic polymeric particulate matter from the deposit. If additional particulate matter…or other materials are in the suspension deposited in the fracture, a matrix or pack of such and proppant…is left in the fracture").

260. Moreover, Palmer refers to "delayed" degradation, and those skilled in the art would understand that the matrix would substantially form before such delayed degradation. Palmer, 2:51–52; *see also* 4:8–12 (particulate should not degrade at a rate faster than desired).

261. Thus, in my opinion Palmer teaches or renders obvious "wherein the degradable material in at least one of the composite particles does not substantially degrade until after the proppant matrix has substantially formed."

Q. Claim 17

Claim 17: The method of claim 14 wherein at least one of the composite particles comprises a material selected from the group consisting of: polysaccharides; chitins; chitosans; proteins; aliphatic polyesters; poly(lactides); poly(glycolides); poly(ε-caprolactones); poly(hydroxy ester ethers); poly(hydroxybutyrates); polyanhydrides; polycarbonates; poly(orthoesters); poly(acetals); poly(acrylates); poly(alkylacrylates); poly(amino acids); poly(ethylene oxides);

poly ether esters; polyester amides; polyamides; polyphosphazenes; copolymers thereof; and blends thereof.

262. *See* discussion of claim 8 above.

R. Claim 18

Claim 18: The method of claim 14 wherein the filler of at least one of the composite particle comprises a component selected from the group consisting of: anhydrous salts; glass; talc; calcium carbonate; mica, magnesium oxide, mineral fillers; barite; silica; ethylenediaminetetraacetic acid; oxidizers; breakers; sodium persulfate; magnesium peroxide; derivatives thereof; and combinations thereof.

263. *See* discussion of claim 9 above.

S. Claim 19

Claim 19[a]: A method comprising:

264. *See* discussion of claim 1[a] above.

Claim 19[b]: providing a treatment fluid that comprises a proppant matrix composition, the proppant matrix composition comprising at least a plurality of proppant particulates and at least a plurality of composite particles,

265. *See* discussion of claim 1[b] above. Although claim 1[b] does not specifically address providing the proppant matrix composition *in a treatment fluid*, Palmer teaches that the proppant matrix composition is a component of a fracturing treatment fluid. *See, e.g.*, Palmer, 2:56–66 (solid particulate is provided in a fracturing fluid with a gellant and proppant, forming a fracturing fluid suspension, and this suspension is pumped downwell and deposited as a gelled suspension in the subterranean formation under fracturing conditions).

266. Thus, in my opinion Palmer teaches or renders obvious the limitation "providing a treatment fluid that comprises a proppant matrix composition, the proppant matrix composition comprising at least a plurality of proppant particulates and at least a plurality of composite particles."

Claim 19[c]: the composite particles comprising a degradable material and a filler material;

267. *See* discussion of claim 1[c] above.

Claim 19[d]: contacting at least a portion of a subterranean formation with the treatment fluid under conditions effective to create or enhance at least one fracture in the subterranean formation; and

268. As noted above, Palmer teaches that the proppant matrix composition is a component of a fracturing treatment fluid that is used "under fracturing conditions." *See, e.g.*, Palmer, 2:56–66 (solid particulate is provided in a fracturing fluid with a gellant and proppant, forming a fracturing fluid suspension, and this suspension is pumped downwell and deposited as a gelled suspension in the subterranean formation under fracturing conditions).

269. Accordingly, in my opinion, Palmer teaches or renders obvious the limitation "contacting at least a portion of a subterranean formation with the treatment fluid under conditions effective to create or enhance at least one fracture in the subterranean formation."

Claim 19[e]: allowing the proppant matrix composition to form a proppant matrix having at least one void therein.

270. *See* discussion of claim 14[d] (with regard to allowing the proppant matrix composition to form a proppant matrix) and claim 1[e] (with regard to forming at least one void in the proppant matrix) above.

T. Claim 20

Claim 20: The method of claim 19 wherein at least one of the composite particles comprises a material selected from the group consisting of: polysaccharides; chitins; chitosans; proteins; aliphatic polyesters; poly(lactides); poly(glycolides); poly(ε-caprolactones); poly(hydroxy ester ethers); poly(hydroxybutyrates); polyanhydrides; polycarbonates; poly(orthoesters); poly(acetals); poly(acrylates); poly(alkylacrylates); poly(amino acids); poly(ethylene oxides); poly ether esters; polyester amides; polyamides; polyphosphazenes; copolymers thereof; and blends thereof.

271. *See* discussion of claim 8 above.

XI. CONCLUSION

I hereby declare that all statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true. Further, I am aware that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001, and with the knowledge that such willful false statements may jeopardize the results of these proceedings. I declare under penalty of perjury that the foregoing is true and correct.

Executed on March, 05, 2018 in Austin, TX.

M. M. Sharma

Dr. Mukul M. Sharma