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An Attempt to Estimate Ultimate Recoverable Resources of Conventional Hydrocarbons in East Coast of India Using Parabolic Fractal Law

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Abstract:

Many aspects of the nature are very complex to understand as they are observed to be random in nature. Concept of randomness is very much prevalent in accurance and finding of oil/gas fields and thus making it difficult to estimate the recoverable resource. An attempt is made in this paper to estimate ultimate recoverable resource of conventional hydrocarbons exploiting the criteria of self similarity in conjunction with parabolic fractal law.

In this paper the self-similarity approach is attempted along with parabolic fractal law to understand the distribution of few gas fields in East coast of India. The paper attempts to obtain the distribution between the gas fields and their respective ranks. As all the numerical methods are bounded by certain limitations on their applicability, the limitation in this proposed method is the number of gas pools available within the field.

Introduction:

Many natural object geometry are well described by a fractal. In particular, fractal self-similarity is a powerful concept that has been investigated by Benoit Mandelbrot. However, in practice the self-similarity law is not always perfectly respected. To remedy to this, Jean Laherrere has proposed the parabolic fractal Law (PFL) which adds a parabolic deviation to the pure self-similar law.

The distribution of gas field sizes is characterized by a few large fields at one end and a large pool of small fields at the other end. This pattern can be closely represented by a self-similarity process. A conventional way to reveal the self-similarity law is to display the log of the ranked field sizes versus the log rank as shown in fig1. If the process is perfectly self – similar the points are distributed along a straight line with -1 slope value.

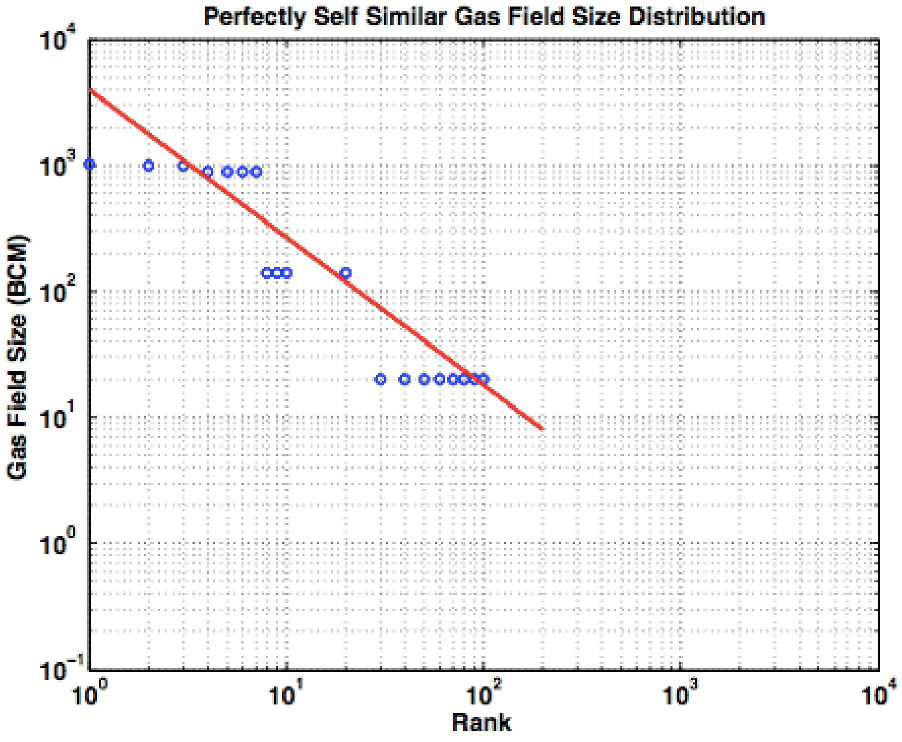

Fig1. Example of a simple self-similar object size distribution represented in a log(rank)-log(size) plane. The red line has a slope equals to -1.

The Parabolic Fractal Law (PFL) is an unperfect self-similar law where a quadratic term is added:

Log(Size(i)) = a+ b. log(i) + c. log(i)^2

Where, Size(i) is the size of the gas field of rank i.

c is the PFL curvature. In case of perfect self- similarity, we have c = 0 and b = -1

Jean Laherrere has estimated the curvature for the world (excluding North America) and came up with a value c = -0.1518/ log (10)= -0.07. Once the PFL parameters are estimated we can derive an URR value by computing the area under the PFL curve given a small field size cutoff:

URR= Sum _ i(a+b.log(i)+c.log(i)^2)

With: a+b.log(i)+c.log(i)^2 > Size_ Min

Application to East coast of India:

Some data about seven Gas fields along east coast of India are as follows:

Field	URR (BCM)
Field1	362.452
Field2	30.014
Field3	15.772
Field4	13.814
Field5	9.257
Field6	6.996
Field7	1.760

Table 1.Size estimates for East coast of India top 7 Gas fields.

Because we have so little data, it will be difficult to reliably estimate a valid parabolic curvature. So we processed as following:

1. The Field URR are ranked according to their size and represented in a log(rank)-log(URR) plane as shown in fig 2.
2. A robust linear fit (no curvature) is applied on the data points (red line on fig 2).
3. A parabolic model is then fitted using the slope established in 2 as first guess for the linear term b and fixed curvature value c (blue lines on fig 2).
4. The URR values are estimated from the areas under the PFL curves conditionally to a particular minimum gas field size as shown on fig 3.

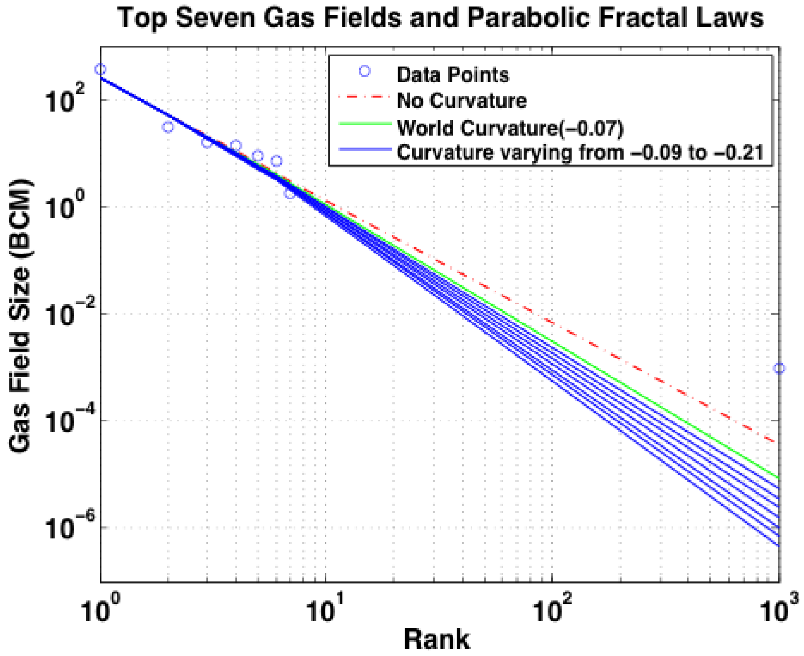

Fig.2. Estimation of various PF laws with different fixed curvature values.

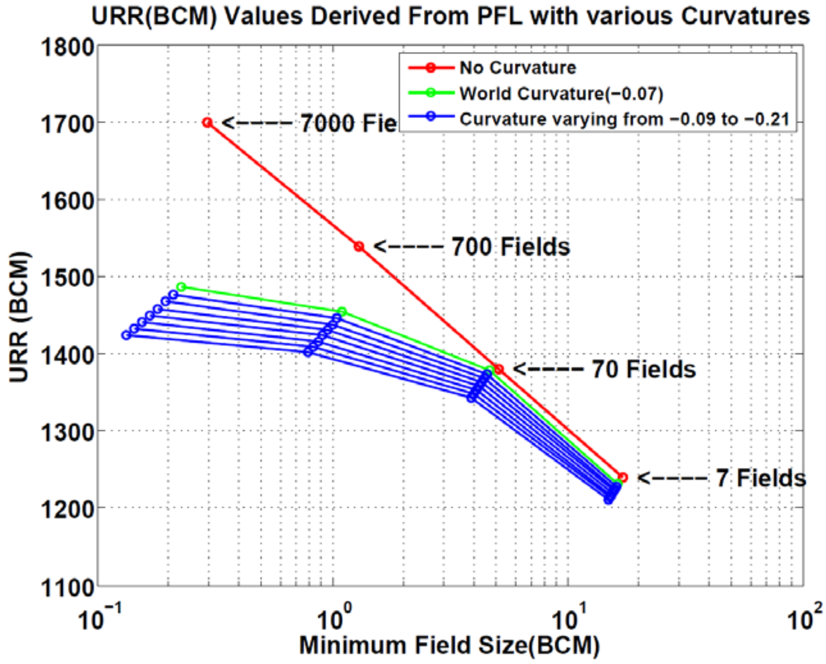

Fig 3. Derived URR from the PFL shown on fig 2. The URR value is function of the minimum gas field size considered

If we fix an arbitrary field size cutoff value at 15 MCM, we get the URR values displayed on fig 4.We can see that using the world curvature at -0.07 we get an URR at 1486 BCM from about 99066 fields. The official URR at 380 BCM would imply a curvature value close to zero around -0.25 with also a much higher number of fields (25333). We can also compare with the estimated URR values, we get using the Hubbert Linearization technique on the production data (fig 5). The first fit (HL1) gives a rather low URR at 12 BCM, which would imply a strong curvature beyond -0.3 with smaller number of fields (<810). The second fit (HL2) gives a rather high URR at 125 BCM, which would imply a strong curvature around -0.3 with rather high number of fields (<8500) and the third fit (HL3) gives a rather high URR at 148 BCM, with a strong curvature around -0.25 with rather high number of fields (>9800)

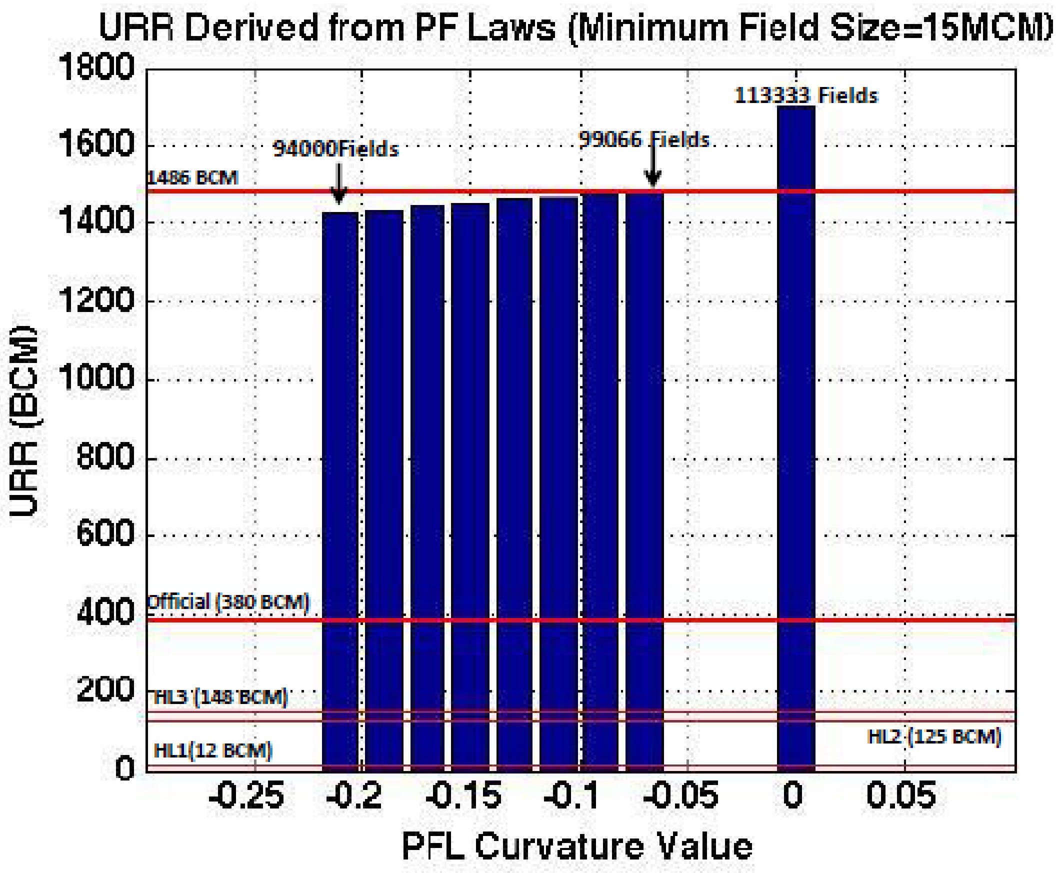

Fig 4. Derived URR from fig 3 by fixing the minimum gas field size at 15 MCM. Hl1 and HL2 are the URR estimate from two different Hubbert Linearizations shown on fig 5.

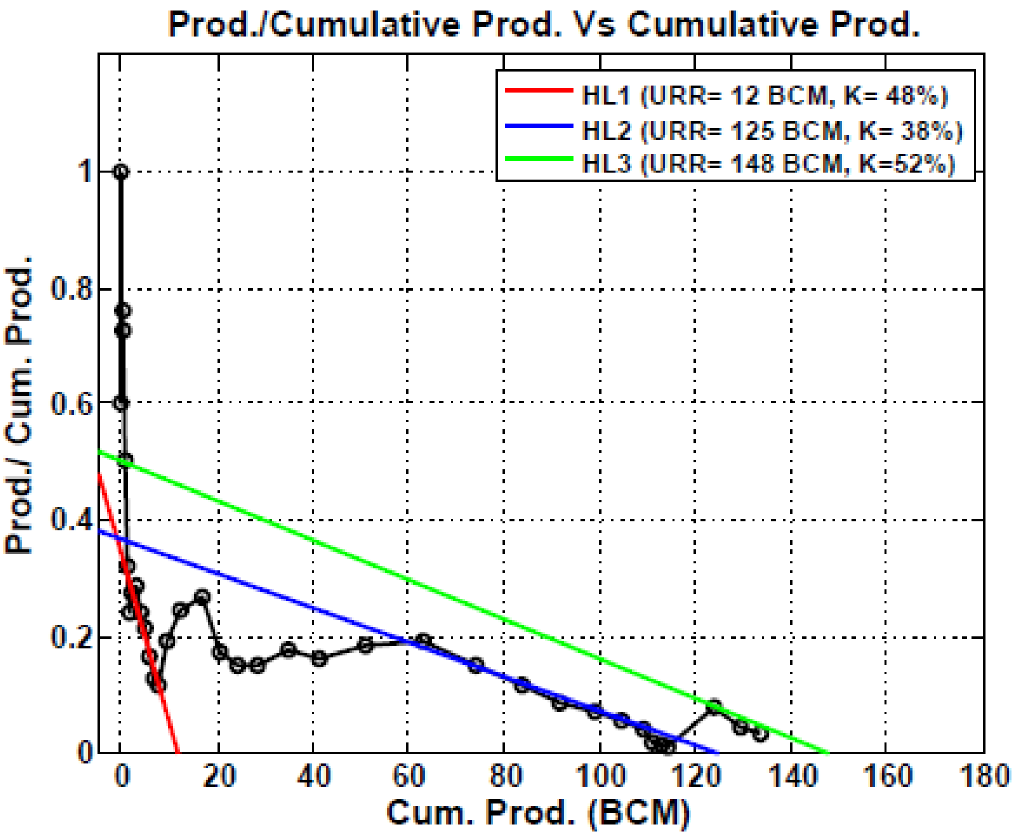

Fig 5. Hubbert Linearizations on East Coast production profile.

Results and Discussion:

- The results are promising despite being based on less number of data.
- It is difficult to understand what is affecting the curvature value. My guess is that the population of small fields is probably less exploited and that less efficient recovery techniques are applied for obvious reasons.
- There is a discrepancy between the URR calculated before the start of the production and the actual production came out from the field. Sometimes the actual production is very less as compared to the expected production. It may be because of the less efficient recovery technology or less exploited reservoir or due to complex geology of the reservoir.

Conclusions:

1. Combined with the Hubbert Linearization technique, the PFL could be useful for tortuous production profiles from immature countries such as India.
2. Only the top fields are necessary for the fit which is interesting because they are usually the most mature and the most documented.
3. The PFL integrates naturally contributions from small fields and the derived URR is dependent on the minimum field size. Therefore, some reserve growth can be simulated by changing the small field size cutoff value.

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