Society of Petroleum Engineers

Speaking About Unconventional Reserves

Director's Notes

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The January issue of JPT integrates the **Technical Directors outlook**, where I referred to issues related to the production analysis and reserves booking of unconventional plays. I have already received quite a few feedbacks, most of them (not all of them!) positive, and I would like to develop a little bit more on this issue. As the article had to be edited for editorial reasons, I would like to start with delivering here my original text:

"Today's development of unconventional resources is based on the drill-and-frac paradigm. We are turning into a mining business where engineering is replaced by process. Whilst companies will spend billions on these wells, asset managers are not incentivized to either invest in proper metrology or to spend time to understand what is really happening in these plays. Smart, young engineers are turned into straight-line operators and are expected to 'process' hundreds of wells a day. The main, if not only technical issue is the value of the 'b' decline exponent (i.e. how exponentially is production decreasing?), but is this the right question today? There may be many embarrassing explanations to give if in a few years it turns out to be irrelevant.

In too many companies, production forecast and reserves booking are based on matching terminal decline curves on two to three years of production data. Yet we KNOW that these very low permeability systems are still in transient phase. Such an exercise, even using additional fiddle factors that were mainly developed to explain the ever-drifting calculations, is technically flawed and should be replaced by an improved engineering methodology.

Even when we try to properly model our systems, we generally assume that fluids are produced from the SRV (Stimulated Reservoir Volume, i.e. the volume of formation geometrically defined by and between the different hydraulic fractures). If we believe this, we expect to repeat the drill-and-frac sequences over the whole formation as if we were building Lego®. Unfortunately unexpected well interference and unwelcome drops in productivity are increasingly challenging this belief. We may think that we are 'creating' the reservoirs by effectively mining them. But these are probably naturally fractured reservoirs that did not wait for us to exist, and we may be draining much more bulk volume than we want to believe. The jury is still out as to whether we shall be in for some surprises in terms of undeveloped reserves and in-fill well performance. So what do we do? Just wait another ten years to find out?

Reservoir engineers and Reserves Groups should sit down together and seriously address the issue. We have the moral duty to warn our stakeholders about what we do and do not yet know. Proper engineering is about narrowing uncertainties by growing knowledge. Understanding unconventional reserves is probably the most exciting reservoir engineering challenge to date. Using empirical curves developed fifty years ago for totally different formations is certainly not a good way to start. We are again in the frustrating situation of the 1970's where we had to 'sell' the long term value of information and science."

Now, as an answer to the first feedbacks I received I will develop a few points:

Reserves on conventional formations were validated for decades by two converging elements: The empirical observation of production decline for nearly a hundred years, and the modelling that was developed in the second half of the past century. Both approaches point to compatible decline responses that are the basis of today's conventional reserves booking. Even if their geneses were very different they do not contradict each other.

For the time being, for unconventional resources, we have neither.

There is too little experience to get credible empirical analogs, and the very slow reaction of these plays does not help. Because of this we may never get any reliable empirical relation. If we get any it may only be play by play, and probably not in our lifetime.

When in SRV-PSS (or pseudo-PSS) flow, using Arps on the linear section of the response seems to be a reasonably conservative thing to do. However several (unfortunately) very popular methods match some stretched curves on earlier

sections of the production decline response, generally adding one more parameter to match the transient behaviour that occurs before this pseudo-PSS.

These additional fiddle factors have no physical meaning and they bring nothing forward. They could be used to retroactively fit the past production, but, to take the well test equivalent, this is as irrelevant as matching the end of wellbore storage after you have reached IARF with a 'S-shaped straight line'. In well test, if you wish to guess permeability and skin a little ahead of true IARF, you carefully use a model.

I really believe it is time to convince the reserve groups to stop this, and I believe that most of them are ready to listen.

Analytical and numerical models are a little better in the sense that they have a physical basis and seem to honour the early observed behaviours. Most of these models are based on the main hypothesis that we can lump the different scales of diffusion into a single equivalent low permeability homogeneous reservoir flowing in relatively simple sets of hydraulic, human created fractures. In these models we ignore the natural fractures and account for desorption with a relatively simple, pressure related change of porosity.

Other applied corrections include stress dependence that generally amount to a constant relation between permeability and pressure. As for the decline curves above, there is a risk that this additional flexibility in the modelling, if not based on lab experiment, could be the excuse for matching other things, such as wells interference.

This is where we are now. However, producing these plays is only starting, and we may need at any time to review our hypotheses. The main worry today is the 'Lego®' thing: Can we rely on this homogeneous equivalent diffusion and this assumption of a SRV geometrically defined by the hydraulic fractures? If so the flow geometry is only imposed by hydraulic fractures. However we may be inducing diffusion through networks of naturally fractures reopened by the hydraulic stress. This may go much further than our hydraulic fractures.

The origin of this worry is what could be interference from other wells. With the values of permeability we are using we should not see them before decades and we see them now. Microseismics often points to events detected much beyond the expected SRV. The current convenient answer is that such events are just stress reactions not reflecting the actual flow pattern. Basically, we rule out any observation that questions our current hypotheses. This is not very good on an engineering point of view, even if it may actually be true.

We are investing very little in metrology in these plays. If this is our 100-year future, we should be investing tons of money and time to try to understand. However today we are basing most of our investment decisions on short term return. Technically, it is as if we were mass-producing modern cars before even test-driving them.

This gets us to reserves booking. We should try to convince the reserve groups to drop Arps except when pseudo-PSS is effectively observed, and to forget about stretched correlations. Until our cumulative knowledge tells us otherwise, we should avoid empirical relationships based on no physical foundation and no long term observation.

Now it is actually not about clear thinking reservoir engineers confronting Luddite reserves analysts. We are all engineers, and most analysts are aware of and worried about today's flaws. The challenge will be to convince managers and regulatory commissions, who are pretty comfortable so far with today's processes, that it is everybody's long term interest to refine get our tools right.

Your comments are welcome. You may leave a note on this page or send me a mail to o.houze@kappaeng.com