Exploration in fold and thrust belts - a personal perspective*

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*Abstract from 2011-2012 AAPG Foundation Distinguished Lecture presentation.

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Twenty-odd years ago we saw fold and thrust belts as part of a 'new geography', sitting alongside the then unexplored deep water continental margins, the Arctic and the liberalising Soviet Union as likely areas to deliver significant new hydrocarbon resources. Since then we have seen political and practical difficulties in many of the countries of the FSSU, and much of the Arctic is only just beginning to get into gear. The deep water passive margins - or at least the inboard, extension dominated parts of them - have delivered abundantly, dwarfing the contribution from the onshore fold and thrust belts. Now, though, these margins are themselves becoming mature, or difficult or expensive to access, and we may need to look again at fold and thrust belts.

Most of us find them exiting. The structures can be large and have the capacity to deliver large volumes of hydrocarbons, but there are also major exploration challenges, which I will try to discuss in this talk.

Fold and thrust belts are geometrically complex, but generally have to be worked with seismic data which are expensive to acquire and often not of the best quality. Even when the pre-requisites of source, reservoir and seal are working in one's favour, the relationship between hydrocarbon maturation, migration and charge with the developing structures is common uncertain. Essentially this is because fold and onshore thrust belts elevate rocks which were once more deeply buried, with consequent damage to the elements of their hydrocarbon systems. It takes a special combination of circumstances to keep a thrust-related structure at maximum burial depth or ensure that structures are developed in time to receive matured and migrated hydrocarbons. Such things happen spectacularly well in the Zagros where over 200 bboe has been discovered – almost equal to the rest of the world's discovered fold and thrust belt resource, but for many other areas, problems can outweigh advantages. Burial, age and structural simplicity are important issues which we need to work in our favour, and often don't.

Petroleum system uncertainties can be addressed by modelling, of course and I will cite an example of a how an integrated dynamic model helped an exploration decision to be made on the fold and thrust belt which forms the eastern margin of the Middle Magdalena Valley of Colombia.

Some of the problems associated with onshore fold and thrust belts are minimised in the toe folds of gravitation systems on the continental margins. They are commonly at maximum burial depth, and the high quality of (relatively cheap) modern marine 3-D seismic data potentially overcomes the imaging problems associated with the onshore, bringing proper structural understanding within reach. Despite this "imaging

advantage", exploration success in toe-fold systems has been modest by comparison to that in the more proximal areas of the same deep water plays. Why? I will argue that it is not entirely a technological issue. Exploration of the world's toe-fold zones exposes us to a different set of geological risks from their onshore counterparts, but they are still significant risks. Two or three prospective and potentially prospective gravitational systems are described in order to illustrate this point.