CO2-SPICER - CO_2 Storage Pilot In a CarbonatE Reservoir

R2.4 Model of spatial distribution and properties of fractures

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CONTENT

1 DATA ANALYSIS

Fracture analysis of a fracture reservoir rock is of course the basis of understanding its reservoir properties. Žarošice field was penetrated by 9 wells, 4 of them are horizontal. Seven of the wells, including the pilot one ZA3, were logged by FMS (by Schlumberger; fig. 1.1). None of the several cores from each well were oriented and the FMS analysis was used as a basis of said fracture analysis.

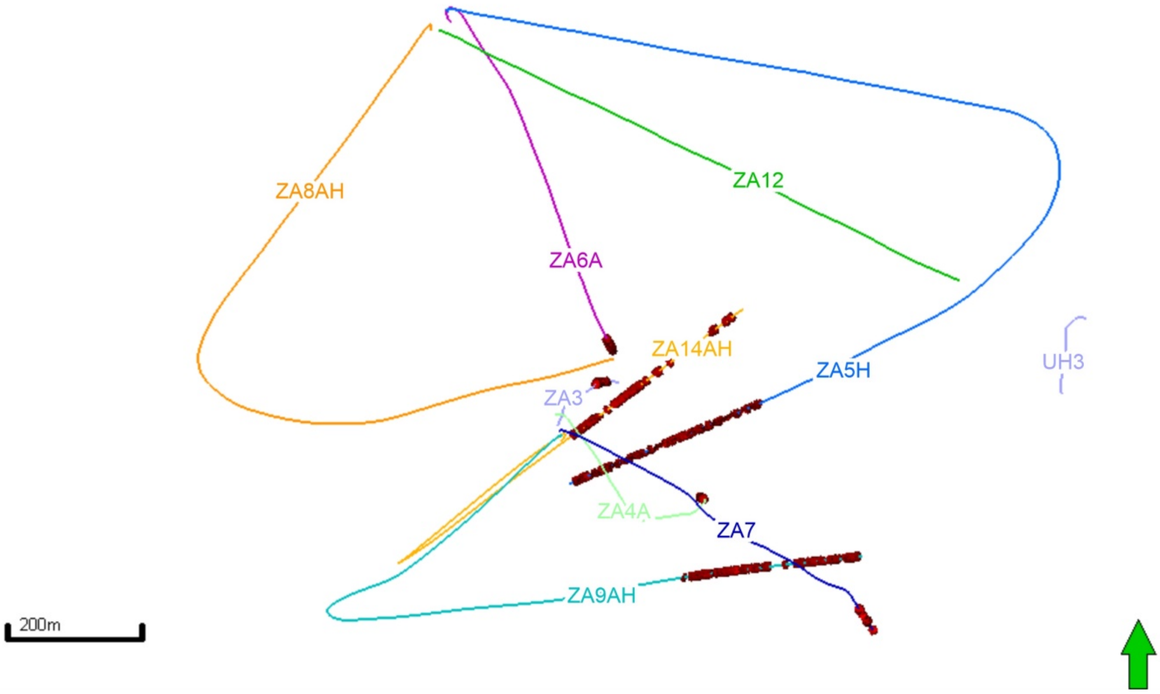

Fig. 1-1: Wells which penetrated the Žarošice field. Red discs are fractures interpreted from FMS data.

All FMS logging was done by Schlumberger as well as the interpretation. Schlumberger data analysts followed a complex protocol of data quality control, explained in detail in every single report, however, as the data was acquired as the wells were drilled during several years of appraisal, the interpretation of FMS varies slightly depending on the experience of the interpreter and of course quality of the data itself. For example, the data quality control did get slightly out of hand in well ZA4A, where the data has a “suspiciously” circular distribution (Fig. 1-2), suggesting logging tool rotation far beyond the tolerance given by Schlumberger (1 rotation per 12 m) or errors of the tool orientation measurements. Such a circular distribution is not present in any other well, again suggesting that the FMS dataset acquired in the ZA4A well should be regarded as a low confidence one and even be discarded. At least the SE cluster (Fig. 1-2b).

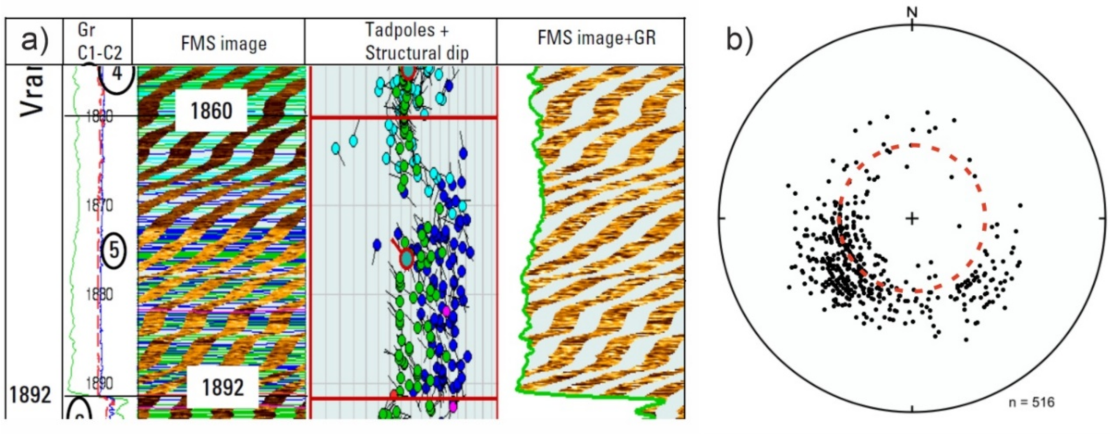

Fig. 1-2: FMS data from ZA4A well. a) primary FMS data from the final report, FMS image shows strong rotation of the tool, however less than 360°/12m, which is the critical value; b) Equal-area plot of “bedding” planes showing very strong circular distribution, highlighted by a red dashed small circle.

Every FMS dataset was interpreted by Schlumberger, yielding several datasets of different tectonic features (bedding planes, assortment of fractures, etc.). All features were statistically evaluated and rotated to geographic coordinates using the well path. The statistical evaluation done by Schlumberger was, however, insufficient, done only via rose plots, which deal only with strikes of analyzed features (basically discarding the whole third dimension of the tectonic planar features framework). This approach of course limits the potential of the data and introduces unacceptable uncertainties, as there can easily be two or more sets of fractures with the same strike but different dips and these cannot be distinguished without the third dimension (i.e. dip; see example in Fig. 1-3). Because of this, contoured equal area plots (lower hemisphere) and other functions of StaTect (www.eltekto.cz) were used for the analysis.

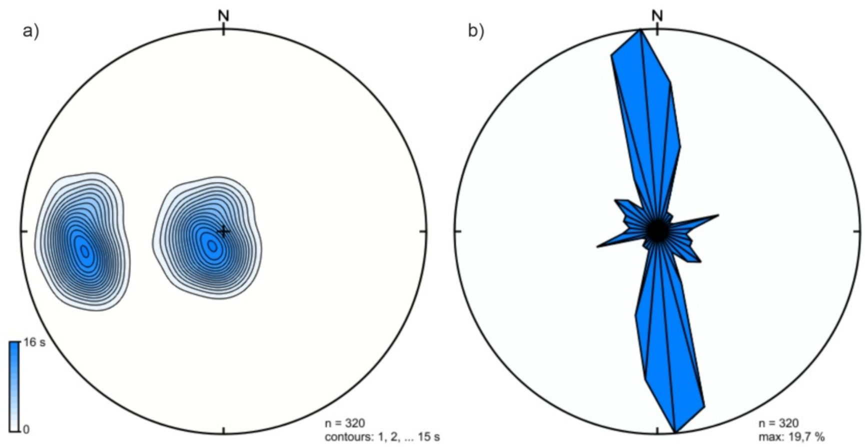

Fig. 1-3: Example of fracture orientation analysis in 3D (a) and 2D (b). The 3D analysis has better resolution.

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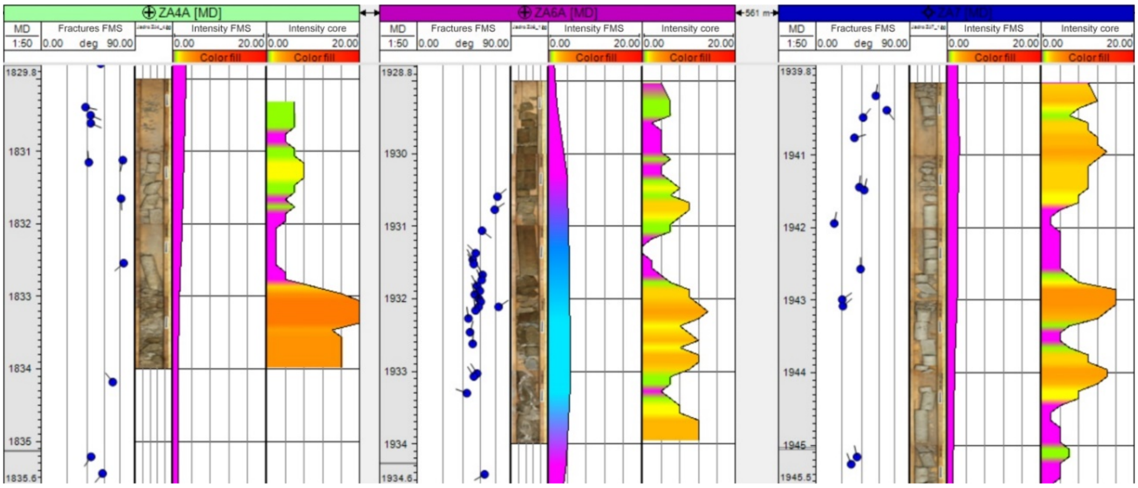

Fig. 1-4: Correlation between FMS (tadpole log) and core fracture data. Note that the intensities from core data (i.e. number of fractures per meter) are 3-10 times higher than FMS intensities.

As was said before, no cores from the Žarošice field are oriented, so they cannot be used for fracture orientation analysis. However, one can compare at least the densities of fractures (Schlumberger Petrel uses the term intensity, i.e. the number of fractures per meter or other set length) defined from FMS data and cores (Fig. 1-4). Fracture densities in cores are 3 to 10 times higher than those derived from FMS and there is no statistically significant correlation between the two densities (Fig. 1-4), so no easy calibration of the FMS data can be done. However, one has to note, that only 4 cores covered by FMS data are available, so no statistically significant conclusions can really be drawn from the different fracture densities derived from the FMS and core data. On the other hand, it is important to point that out and keep it in mind during further analyses and risking estimates.

Tab. 1-1: Features interpreted from FMS data: • (dark grey) Paleogene • (green) Mikulov marl • (pink) Vranovice dolomite • (yellow) "sandy horizon" • (blue) Nikolčice beds • (light grey) Culmian basement

Fracture/well	ZA3	ZA4A	ZA6A	ZA7	ZA5H	ZA9AH	ZA14AH
bedding	• (dark grey) • (pink)	• (pink) • (yellow) • (blue) • (light grey)	• (pink) • (light grey)	• (pink) • (blue) • (light grey)	• (pink) • (yellow) • (blue) • (light grey)	• (pink) • (green)	• (pink) • (yellow)
low confidence bedding	• (dark grey) • (pink)						
conductive fractures	• (dark grey) • (pink)	• (pink) • (yellow) • (blue) • (light grey)	• (pink) • (light grey)	• (pink) • (blue) • (light grey)	• (pink) • (yellow) • (blue) • (light grey)	• (pink) • (green)	• (dark grey) • (pink) • (yellow)
resistive fractures		• (pink) • (yellow) • (blue) • (light grey)	• (pink)		• (pink) • (yellow) • (blue) • (light grey)	• (pink)	• (dark grey) • (pink) • (yellow)
solution enhanced fractures				• (pink)			• (pink) • (yellow)

Several types of planar features were interpreted from the FMS logs, which are summarized in Table 1-1. FMS data do usually cover the oil zone of the field, some cover also the cap rocks (i.e. Paleogene and Mikulov marl) and some the bedrock (i.e. Culmian facies, greywackes and conglomerates). Fractures and bedding are discussed in their respective chapters.

1.1 Bedding

1.1.1 Reservoir

Reservoir rocks comprise two or optionally three layers: Vranovice dolomite and underlying Nikolčice beds. A third "layer" usually within the Vranovice dolomite or on its base can be distinguished, so called „sandy horizon“. This horizon can be probably assigned to the Nikolčice beds (which themselves show lateral facial instability), but it is slightly different (lower gamma ray and density values). For the purposes of this analysis, it will be treated as a distinct layer, because no matter to which formation it "belongs" it highlights facial diversity of the basal parts of the reservoir.

Low confidence bedding planes were interpreted from the FMS data in well ZA3. However, it is clear that they have the same preferred orientation as "normal" bedding planes (Fig. 1-5), so they will be treated as normal bedding planes.

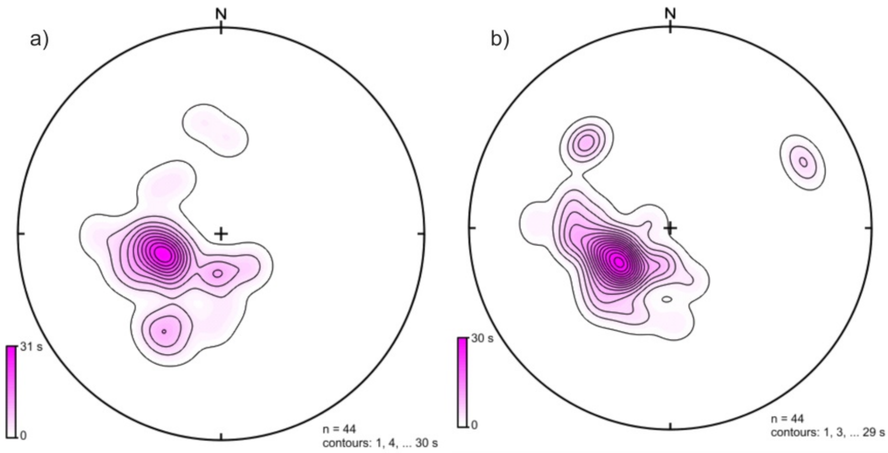

Fig. 1-5: Contoured equal area plots: a) bedding planes of Vranovice dolomite in ZA3 well; b) "low confidence" bedding planes of Vranovice dolomite in ZA3 well.

FMS analysis from the ZA7 well yielded very little data in general and bedding planes in particular. Therefore, this data was not contoured in Fig. 2-2.

ZA5AH FMS data was obviously misinterpreted. All three reservoir rocks show a very similar pattern with two major maxima, one oriented 236/45, which is coherent with bedding planes maxima of most other wells, and a second one, even more pronounced, oriented 129/2. This was interpreted by Schlumberger as NE-vergent folds with NNE plunging axes (ca 37/54; Fig. 1-6). This would do as a stand-alone interpretation, but it does not fit in the context of the whole field. No such fold structure was found anywhere else in the field, but rather a monoclinal structure dipping to the E. Thus a more likely interpretation of the NE-SW striking subvertical planes is that they are simply fractures and were misinterpreted as bedding planes.

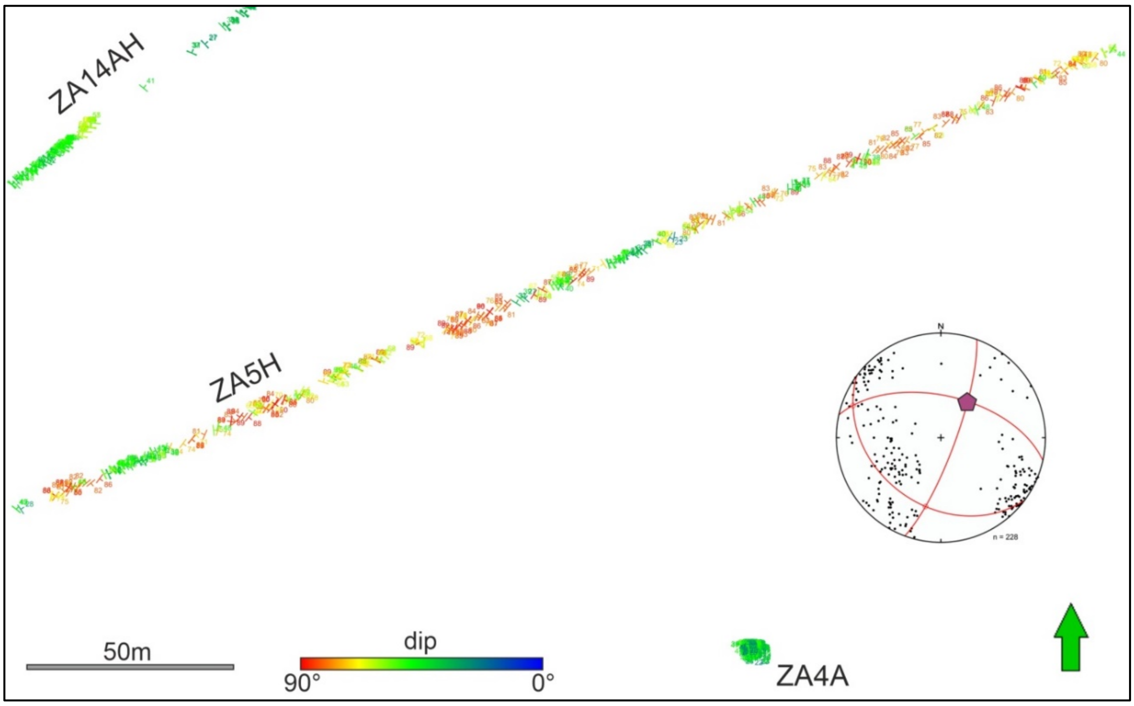

Fig. 1-6: Structural map of bedding planes of ZA5H well and its nearest vicinity. Dips of the bedding planeness are color-coded for convenience. Violet pentagon in the equal-area plot of bedding planes poles denotes the mean fold axis (third eigenvector of the orientation matrix).

If we discard all erroneous data, namely data from ZA4A well and the NW-SE cluster from ZA5H well, we get a more or less monoclinal bedding slightly dipping to the E to NE (Fig. 1-7) in all three main reservoir rocks. This bedding roughly matches the overall orientation of the bedrock (Fig. 1-8). This suggests that the planar features interpreted as bedding planes can realistically be the bedding planes, at least in the Nikolčice beds and the “sandy horizon”, which have the bedding more pronounced. However, no bedding planes can be spotted in the core material of the Vranovice dolomite, suggesting that it is rather massive. What can be observed, however, are numerous fractures across the cores at angles 45 to 90 °. These fractures could have been misinterpreted as bedding planes. Either way, these fractures or bedding planes are obviously opened and should be treated as another fracture set in fracture modelling.

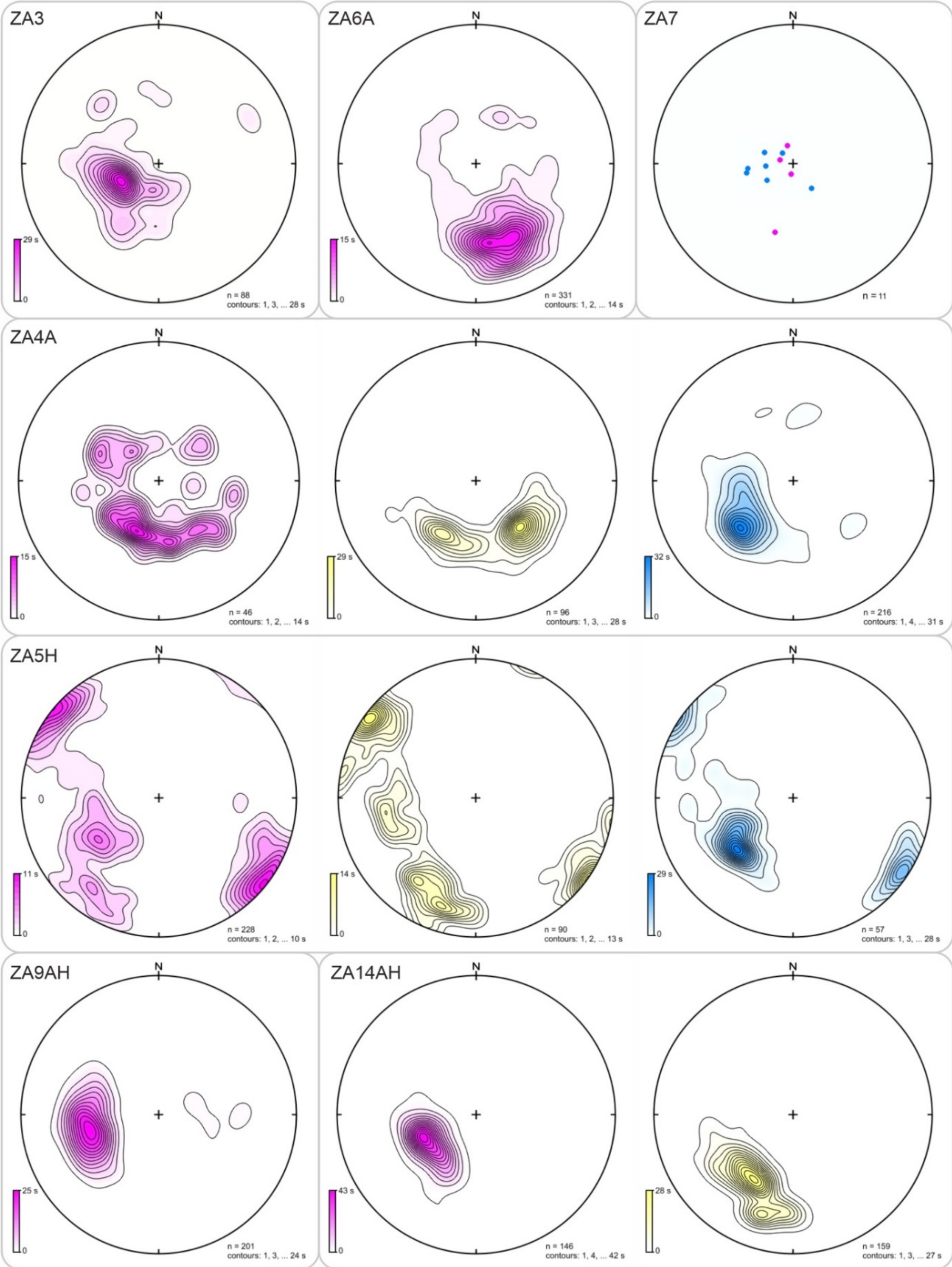

Fig. 1-7: Bedding planes data from FMS from wells in the Žarošice field. Reservoir rock types are color-coded: violet is the Vranovice dolomite, yellow the "sandy" horizon and blue are the Nikolčice beds.

1.1.2 Cap and basement rocks

A much clearer picture is drawn by the bedding plane data from the cap rock and the basement. Most of the cap rock in the west part of the field is formed by Paleogene mudstones. FMS data from ZA3 well show very monotone bedding planes orientation – 17 ° to the west. Mikulov marl forms the cap rock in the eastern part of the Žarošice field and according to FMS data from ZA9H well forms also a very monoclinal structure which dips to the east (47 °). This is concordant with the bedding in the reservoir rocks, and can be explained by tilting of the whole fault block of the Žarošice field on a listric fault.

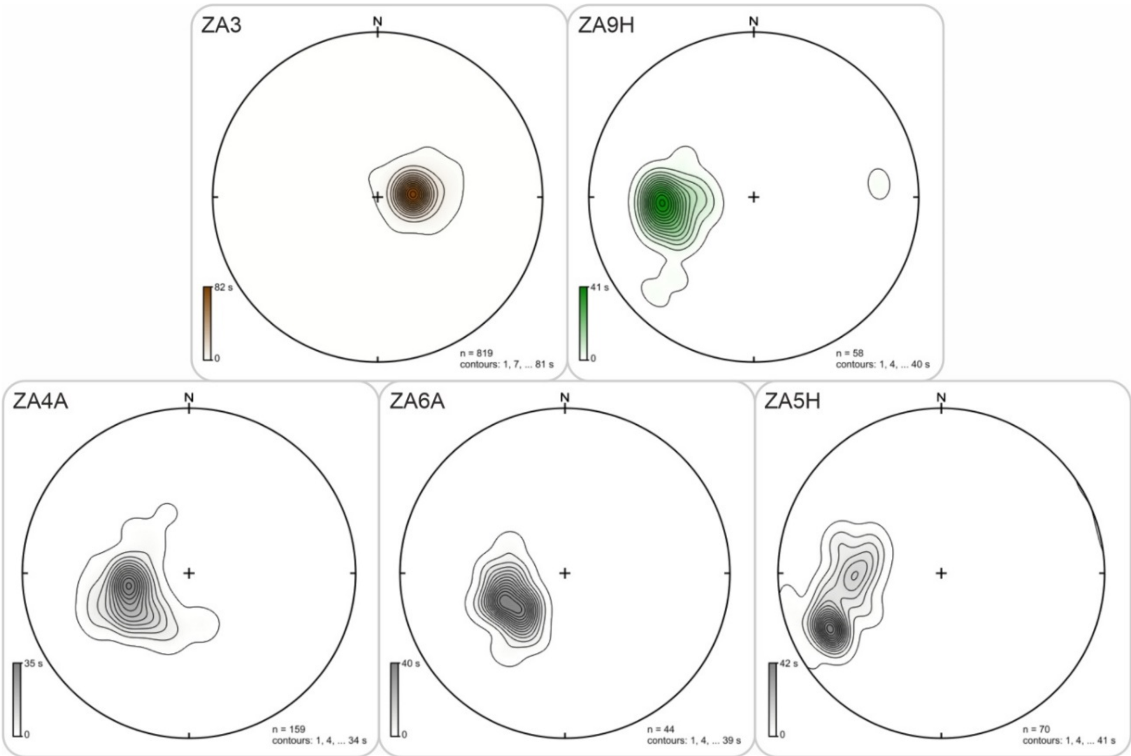

Fig. 1-8: Bedding planes data from FMS from wells in the Žarošice field. Cap and basement rock types are color-coded: brown is the Paleogene, green the Mikulov marl, grey the Culmian rocks.

The basement of the Žarošice field is a deeply eroded Variscan thrust belt formed by greywackes and conglomerated of the Culmian flysch and by limestones of the Macocha Formation in the UH3 well vicinity. FMS data from the Culmian rocks show quite a monotone structure gently dipping to the E to ESE. This is highly unlikely, because it is a deeply eroded thrust unit with complex thrust-fold structure. Limestones drilled by the UH3 well suggest that the Culmian rocks beneath the field are very close to the basal Variscan detachment (the Culmian rocks are thrust over the limestones of the Macocha Formation). The “bedding planes” interpreted from the FMS data are then more likely the basal mylonitic thrust zone or a misinterpreted set of fractures which happen to have a similar orientation as the overlying Jurassic.

1.2 Fractures

Three types of fractures were interpreted by Schlumberger from the FMS data (Tab. 1-1). **Conductive fractures** are features that crosscut the bedding and display a dark resistive contrast. They can either be opened to fluid flow and consequently filled with drilling fluid or closed to fluid flow and filled with clay minerals. However, no clay minerals were observed smeared on fractures in the core material, so one can safely assume that the conductive fractures are opened for fluid flow and are the main component providing permeability for the Vranovice dolomite.

The second type is the **resistive fractures** which have a bright resistive contrast to the surroundings. According to Schlumberger they are most likely cemented joints sealed to fluid flow. However, no veins as such can be observed in the core material.

The third type is **solution enhanced fractures**. They have been interpreted only in 2 wells – ZA7 and ZA14H as fractures leached by water circulation. No such leached fractures can be observed in the core material and these fractures should be treated as "normal" conductive fractures.

1.2.1 Reservoir

Unlike the bedding planes, fractures were in most cases analyzed for all three reservoir rocks together, because a quick initial analysis showed that the fractures have basically the same orientation in all three of them and analyzing them together yields statistically more significant results. All **resistive fractures** data is summarized in Figure 1-9. Contoured plots show a variety of fracture systems, mainly sub-vertical or steeply inclined. All main density maxima (fracture systems) are summarized in Tab. 1-2.

Tab. 1-2: Systems of conductive fractures from FMS data (normals!).

ZA3	ZA4A	ZA6A	ZA7	ZA5H	ZA9AH	ZA14AH
156/19	344/36	180/12	166/66	223/13	5/5	89/23
171/19	9/32	51/25	324/28	293/16	189/6	107/10
147/35	32/38	0/39	47/29	246/50	200/27	262/17
17/20	143/31	348/24	357/57	128/16	79/30	68/69
	178/35	337/25	346/50	126/2	247/32	
	229/32					

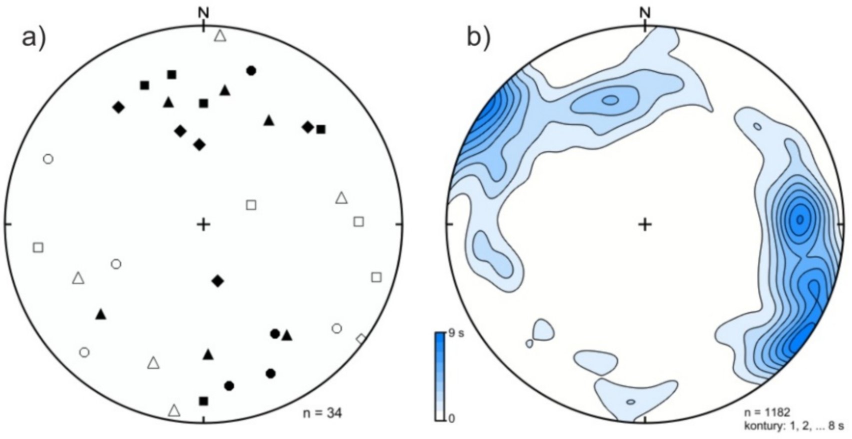

Fig. 1-9: a) All density function maxima/fracture sets based on Fig. 1-10; b) Contoured equal area plot of all conductive fractures (including data from ZA5H well wrongly classified as bedding).

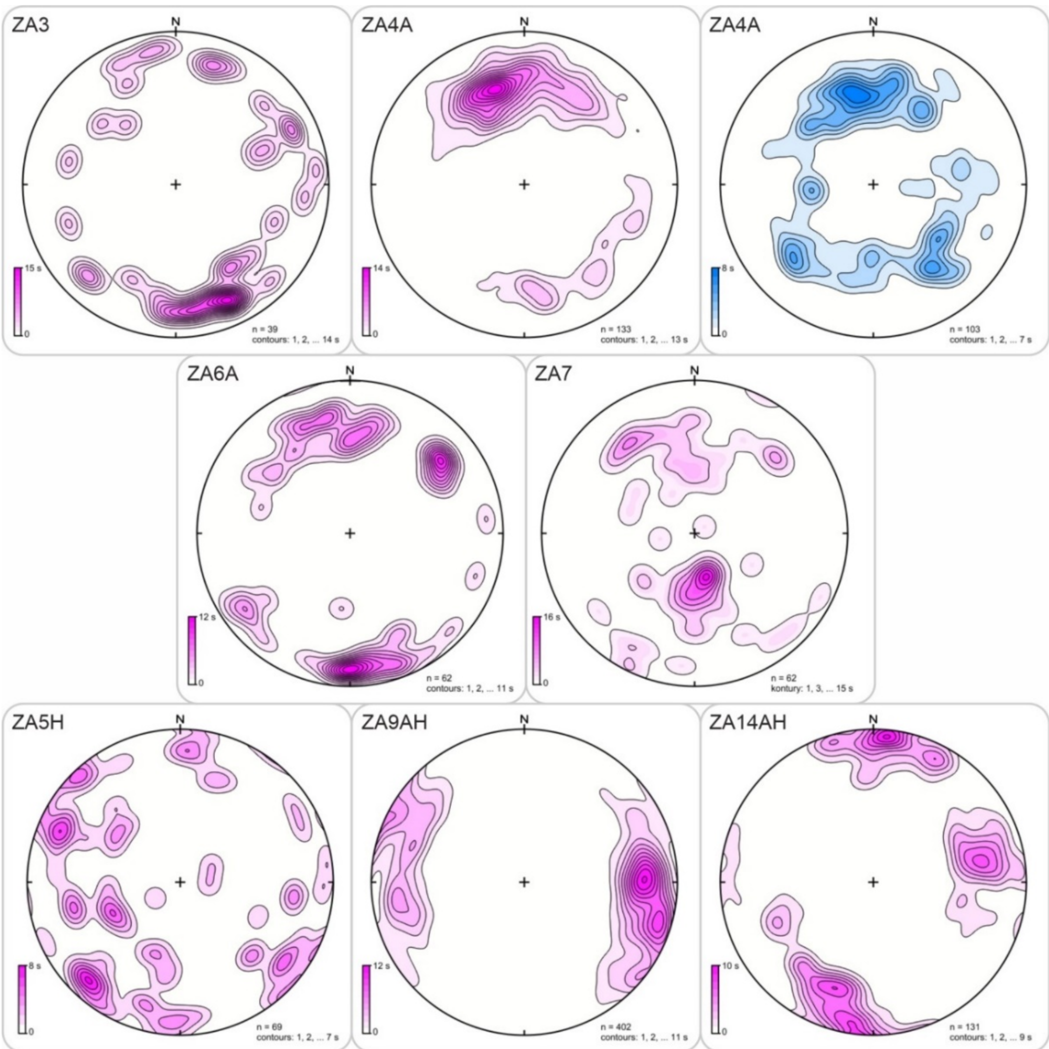

Fig. 1-10: Contoured equal area plots of conductive fractures in reservoir rocks. Violet ones are either contoured plots of all of the reservoir rocks present in that particular well or for Vranovice dolomite in ZA4A well. Blue contoured plot is for the Mikulov marl.

Equal-area plot with all resistive fracture systems from table 1.2 (fig. 1.9a) shows a plethora of different fracture sets. Most of them are, however, quite steeply inclined. The main fracture systems seem to be W-E striking fractures inclined towards north and south (2 systems) followed by N-S fractures (again two systems inclined towards E and W). Contoured plot of all conductive fractures suggest otherwise, but only because of the dataset from ZA9AH well, which is order of magnitude bigger that the other datasets and “drown” the other maxima. A third major system seems to be the fractures from ZA5H well wrongly classified as bedding planes. This makes it five major fracture systems and several more minor ones.

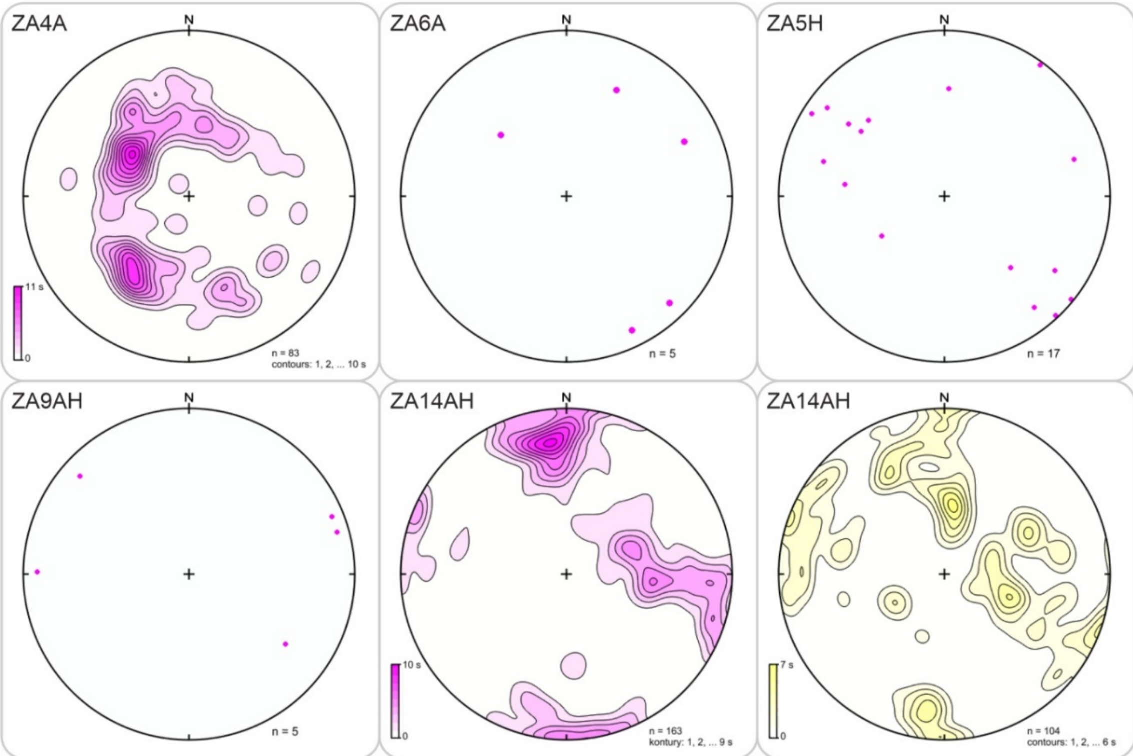

Fig. 1-11: Equal area plots of resistive fractures in reservoir rocks. Violet ones are either plots of all of the reservoir rocks present in that particular well or for Vranovice dolomite in ZA14AH well. Yellow contoured plot is for the “sandy horizon”.

Resistive fractures were by Schlumberger classified as cemented fractures (veins) most likely closed for HC flow. However, there is no evidence in the core material to support this statement. Unfortunatelly no core did sample the areas of the highest densities of resistive fractures, so we really do not know their true nature. Luckily there are only two wells with relatively high numbers of these fractures, the rest of the wells have statistically insignificant numbers of them (Fig. 1-11). It can be observed, that the resistive fractures have very similar orientations as the conductive fractures (statistically speaking). So a question naturally arises wheter the resistive fractures in these two wells are indeed cemented or simply misclassified, which seems more likely.

The last category is the **solution enhanced fractures**. They have been interpreted only in 2 wells – ZA7 and ZA14H (Fig. 1-12) as fractures leached by water circulation. No such leached fractures can be observed in the core material and these fractures should be treated as “normal” conductive fractures.

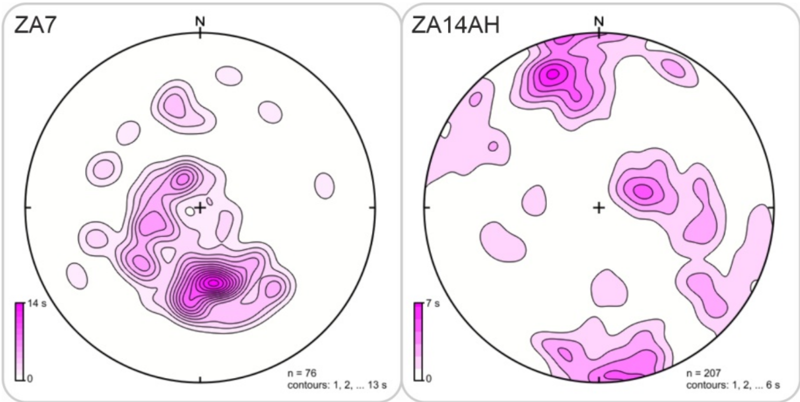

Fig. 1-12: Contoured equal area plots of solution enhanced fractures.

1.3 Cap rock and basement

A small portion of both the cap rock and the basement was also logged by FMS. The results are not statistically significant, because a very small number of fractures was defined, however, they provide us at least a glimpse into the brittle deformation of cap rocks (Paleogene and Mikulov marl) and basement (Culmian facies). It is important to note, that the low number of joints in both cap rocks is partly due to relatively low brittle deformation in those rocks, but mainly due to very short intervals with FMS data (9 m in ZA14AH, 12 m in ZA9AH). The only usable interval is the Paleogene from the ZA3 well where FMS covers the whole interval of Paleogene (108 m). 23 fractures were interpreted from the FMS data, showing an order of magnitude lower intensities than the Vranovice dolomite interval (Fig. 1-13).

Paleogene cap rocks show quite consistent fracture framework of four subvertical systems of fractures basically perpendicular to each other (Tab. 1-3, Fig. 1-14). Only four fractures were measured in the Mikulov marl, so no conclusions can be drawn from that dataset, other that all of them are almost vertical N-E striking and compatible with one of the sets defined in the Paleogene rocks.

Tab. 1-3: Systems of conductive fractures from FMS data (normals!). ZA3 and ZA14AH from the cap rock, ZA4A and ZA7 from the basement.

ZA3	ZA14AH	ZA4A	ZA7
354/41	354/23	25/38	344/45
131/46	82/14	274/48	22494
242/43	229/36	58/35	255/63
51/28		349/41	267/41
		238/46	102/26

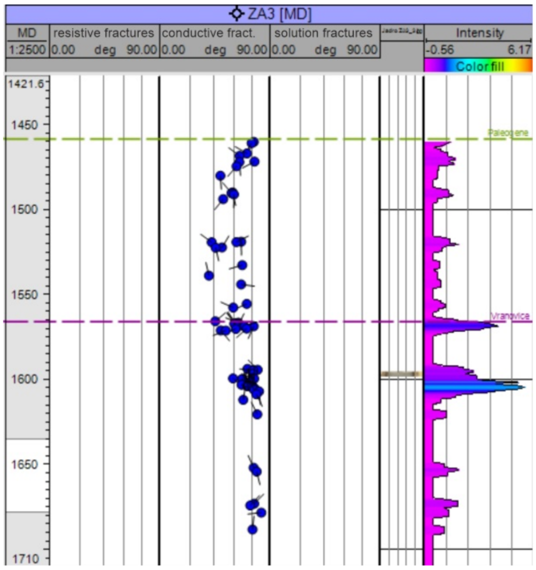

Fig. 1-13: Intensities of conductive fractures in well ZA3.

Culmian basement rocks were logged more extensively in longer intervals. FMS analysis of three intervals yielded over 170 conductive fractures. The dataset from ZA4A well looks again very suspicious, so no particular attention should be paid to it. ZA7 dataset yielded 5 fracture sets, two main ones are W-E striking and are almost perpendicular to the bedding planes.

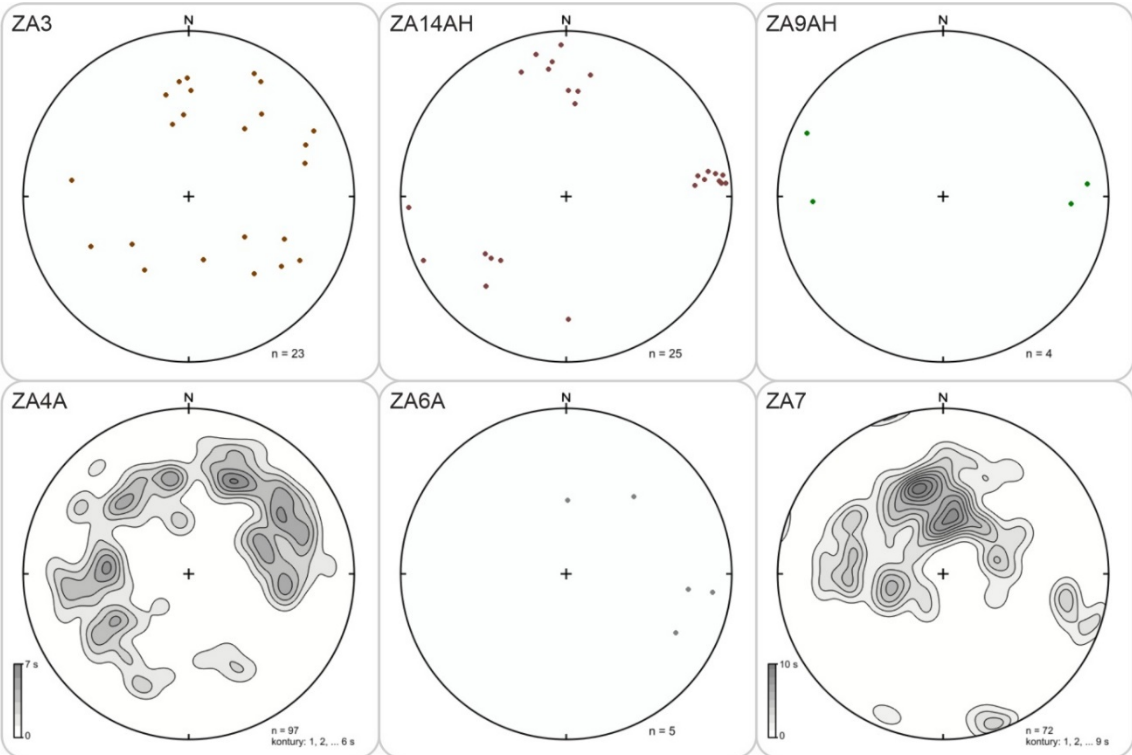

Fig. 1-14: Conductive fractures data sets from cap rocks and the basement: ZA3 and ZA14AH from Paleogene and ZA9AH from the Mikulov marl, ZA4A, ZA6A and ZA7 from the Culmian basement.

1.4 Summary

- Quality of the dataset from ZA4A well seem to be questionable. The log tool rotation was either recorded incorrectly or some other error did occur, as suggested by the suspiciously circular distribution of most recorded features. This dataset should not be used for fracture modelling. A fracture dataset could be simulated using fracture orientation form other wells and intensities from ZA4A well, if the fracture modelling would have insufficient data in that part of the field.
- All cores exhibit much higher fracture densities (intensities) than FMS data. No correlation between core fractures and FMS fractures densities can be found, because of insufficient data. It is not clear how to deal with this problem, because the FMS based densities cannot be calibrated by the core data.
- Bedding planes interpreted from FMS in well ZA5H seem to be misinterpreted. There is a big cluster of subvertical NE-SW striking planes that are not consistent with the overall bedding pattern and should be reinterpreted as conductive fractures.
- A large number of features in FMS logs were interpreted by Schlumberger as bedding planes. Drill cores, however, do not show much more than a hint of bedding – Vranovice dolomite appears to be massive rather than layered. On the other hand, the FMS based bedding planes follow the overall dip of the base of Jurassic strata and also bedding planes in Nikolčice beds, which are usually layered. So there is a possibility, that the planes interpreted as bedding are indeed bedding planes (they also could have been interpreted as bedding planes based on bedding in the Nikolčice beds as FMS interpretation can be a very subjective process). However, these planes are most likely fractures and should be incorporated into the fracture model as conductive fractures.
- Conductive fractures are the most important features for reservoir properties. Five major systems can be defined based on the FMS data with several more minor ones. The orientation of said major systems are 127/2, 88/23, 344/35, 254/26, 185/11. Fracture modelling should of course be based on “real” fractures derived from FMS data in each well as well as their densities.
- Resistive fractures were interpreted by Schlumberger as cemented and closed to fluid flow. As they are not numerous, they should not enter the fracture modelling, however, a broader discussion should be initiated about resistive fractures in wells ZA7 and ZA14H, because they are much more numerous than in other wells and based on their orientations, there is a strong possibility, that they were misinterpreted and should enter the fracture modelling as “normal” fractures opened to fluid flow.
- Solution enhanced fractures should be reinterpreted as conductive fractures and used as such in fracture modelling, because there is no evidence in the cores of fracture leaching or any other solution process.

2 FRACTURE MODELLING IN PETREL

2.1 Standard algorithm

Fracture modelling for the purposes of reservoir properties estimation and distribution was done in Petrel following a standard workflow suggested in the software. Petrel cannot use the FMS data directly in a deterministic fashion but has to use a stochastic model based on statistical characteristic of the data. The procedure is hence as follows:

1. Dividing the FMS fractures into groups using a cluster analysis (Figs. 2-1a, 2-2a)
2. Calculating intensities for each fracture cluster (Figs. 2-1b, 2-2b)
3. Generating synthetic fracture sets based on the clusters (1) and their intensities (2) and other statistical inputs such as fracture apertures and size of fractures.
4. Upscaling fractures to the grid calculating porosities and permeabilities during the process.

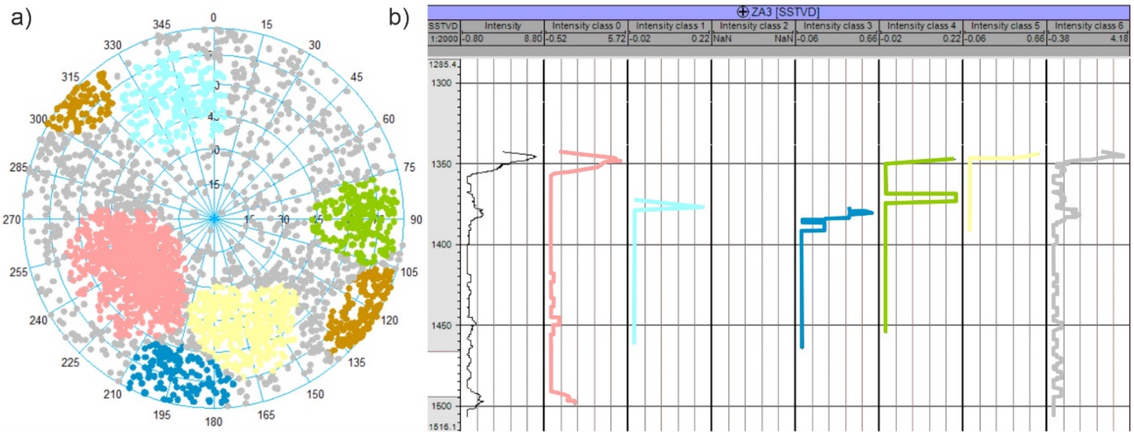

Fig. 2-1: Fracture systems defined using FMS data: a) equal-area plot of poles of all fractures; b) example of intensities from ZA3 well: the first track is the intensity of all fractures, the rest of tracks are individual fracture sets color-coded accordingly the colors in the equal-area plot (note, that the class 2, brown, is only in well ZA5H, hence the empty track).

All planar features described in chapter 1 were classified as fractures in the fracture modelling based on the arguments listed in the summary. All clusters of data described above were reduced / merged into 7 main systems, 6 clusters of data and the seventh is the "noise" – data without any preferred orientation (Tab. 2-1). For all seven systems, intensities were calculated. These clusters were used as input parameters for the stochastic generation of fractures in the model. The mean cluster orientation calculated the orientation matrix was the main orientation input as well as the concentration parameter κ, a key parameter in the Fisher function used to simulate the data "dispersion" (the bigger the number the more concentrated the cluster is). These fractures were distributed according to the intensity of each fracture system. The apertures tab was for the first iteration "as is" to test just the distribution aspect of the fracture model.

Tab. 2-1: Summary of fracture systems evaluated using FMS data and used in fracture modelling.

fracture system	mean orientation	concentration
0	55/40	15
1	165/56	45
2	302/88	45
4	5/73	35
4	265/65	40
5	332/45	40
6	70/7	1

Resulting fracture network was, however, limited only to the cells penetrated by wells with FMS data (Fig. 2-2c). Up to Petrel 2019, the only way how to circumvent this problem was to increase the size of fractures (not the apertures). This resulted in unrealistically long (several km) thin fractures. In the latest versions of Petrel, however, it is possible to generate realistically sized fractures in the whole volume of the grid. The workflow is similar to the shown above, with only one more step before the generation of fractures. One has to distribute the fracture intensities of every defined fracture system based on their orientation and dispersion (i.e. the angular size of the cluster; example in Fig. 2-2d) and then use the distributed intensities as an input of the fracture modelling. This results in a more realistically sized fractures. However, it also yields huge numbers of fractures – 23 000 000 which are almost impossible to handle, let alone to upscale them into the grid (all attempts crashed after ca 6 hours of upscaling runs). This rendered this approach unusable. And this was done on a previous iteration of the model with the grid size of 25x25 m (ca 800 000 cells). The current grid with over 136 million cells would be too much even for the most powerful computers (Petrel is sadly single core…). An attempt to increase the intensities of fractures was done. As mentioned above, no discernable relation between intensities of fractures from FMS data and cores can be found (Fig. 2-3). An average of 4.6 was tested to multiply the intensities, but it was not enough (Fig. 2-4 third track).

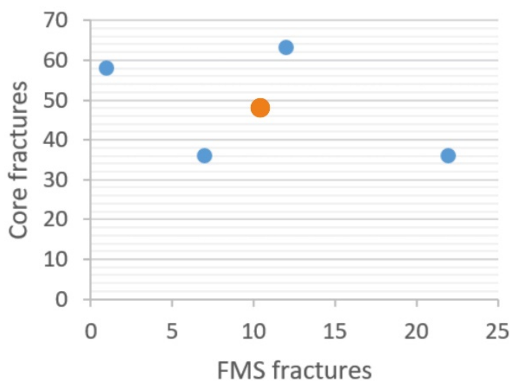

Fig. 2-3: Relation between FMS fracture intensities and core fractures intensities. Orange circle is the average of the 4 blue points.

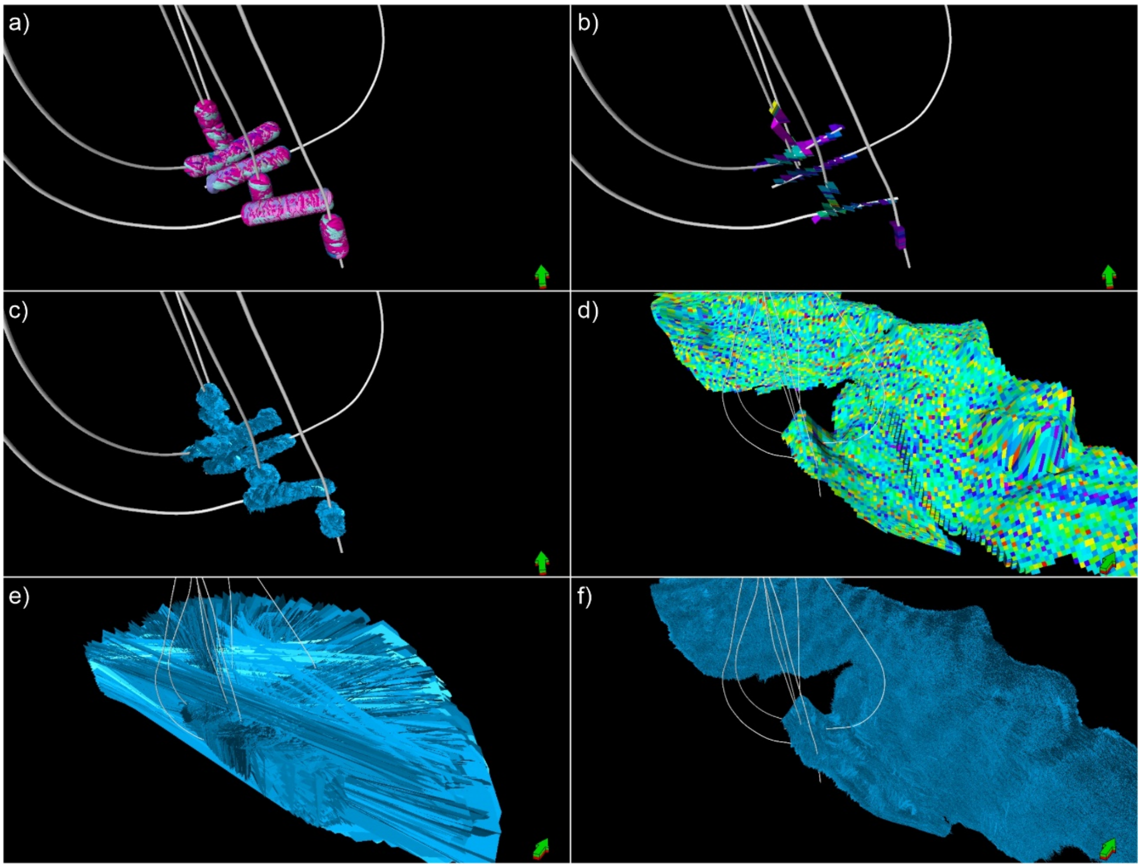

Fig. 2-2: Fracture modelling workflow. a) FMS fractures on wells color-coded by the fracture system; b) fracture intensities upscaled into the model grid (example of the first fracture system intensities); c) Fractures generated using a stochastic model based on FMS data; d) example of the first fracture system intensities distributed into the whole grid based on its statistical characteristics; e) fracture model where the coverage of the whole grid was achieved by increased size of fractures; f) fracture model based on fracture intensities distributed over the whole grid.

A second problem arose during testing parameters using the more computer friendly method mentioned in the beginning of the chapter. Fracture apertures are crucial for reservoir properties estimations. They control both the porosity and permeability. Unfortunately, there is no data on fracture apertures from the Žarošice field, because all cores are disintegrated. A single value of aperture was used for all fractures due to this lack of data. Extensive testing was necessary to find suitable values of apertures by trial and error. Despite all efforts, no suitable parameters were found. Either the porosities were too little and permeabilities were reasonable or porosities were acceptable, but the permeabilities were through the roof, so to speak, they reached values of 10^7 D (Fig 2-4). Also, no data on fracture roughness is available, so no coefficient decreasing the sky-high permeabilities can be applied.

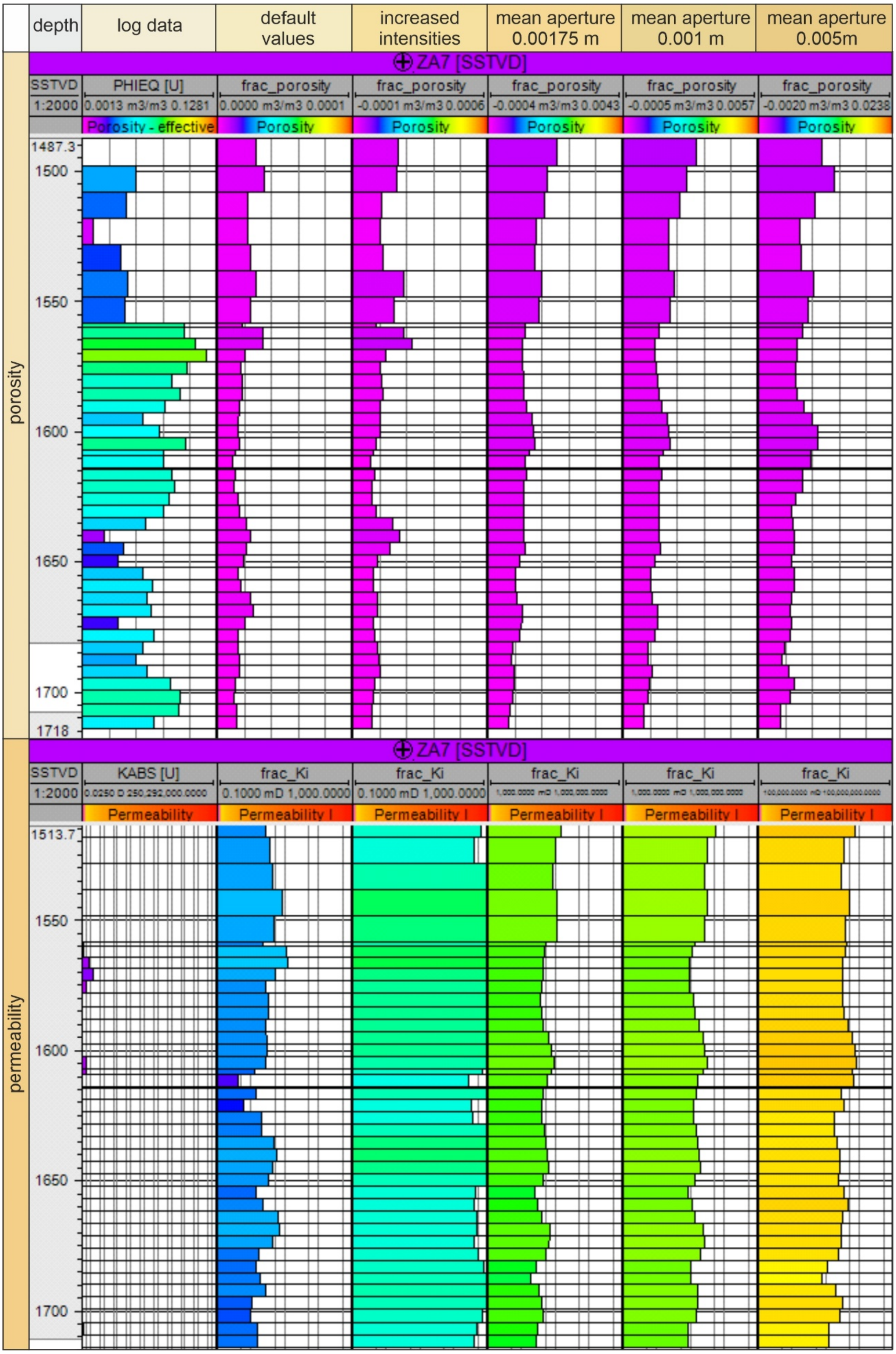

Fig. 2-4: Comparison of reservoir properties in ZA7 well from log data analysis (left most tract) and different iterations of fracture modelling.

2.2 Alternative algorithm

A third method of fracture modeling was devised to overcome difficulties mentioned above. Since all the intensities of corresponding fracture systems have to be distributed throughout the grid anyway, one can easily calculate the total intensities for each cell and then find some way how to calculate porosities and permeabilities from those, since even in the previous attempts one had to use a singular value of apertures due to a lack of data on apertures from core material. The only data available for such correlation is the porosities and permeabilities from log data interpretation. If we plot the reservoir properties against the intensities for each well, we can see some sort of a correlation (Fig. 2-5). A simple linear regression gives us the necessary formulas to calibrate the relation between fracture intensities and reservoir properties. However, these two data sets (log and intensities reservoir properties distributed to the grid) do not correlate with each other (Fig. 2-6a). An example in Fig. 2-6b shows ZA7 well where the correlation seems the best.

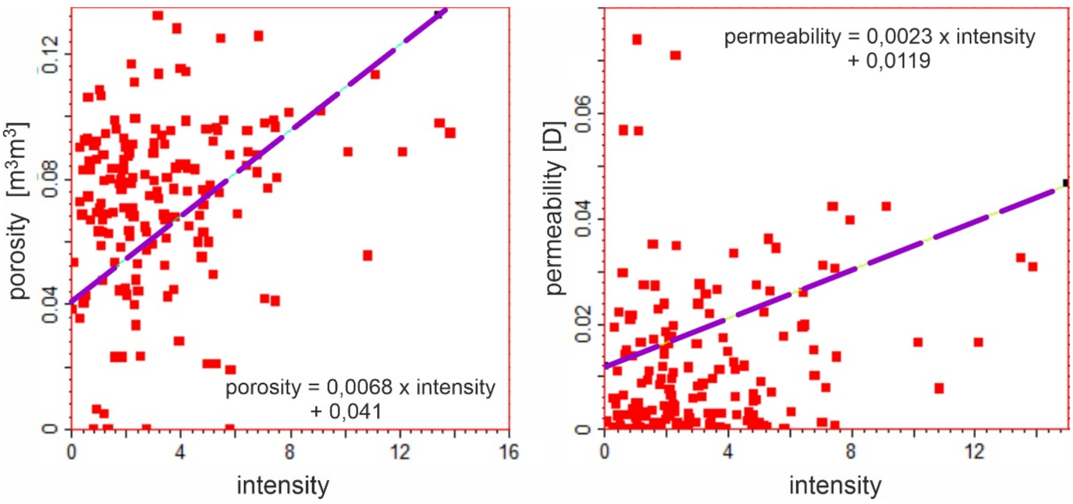

Fig. 2-5: Correlation between reservoir properties from log data and fracture intensities on all wells.

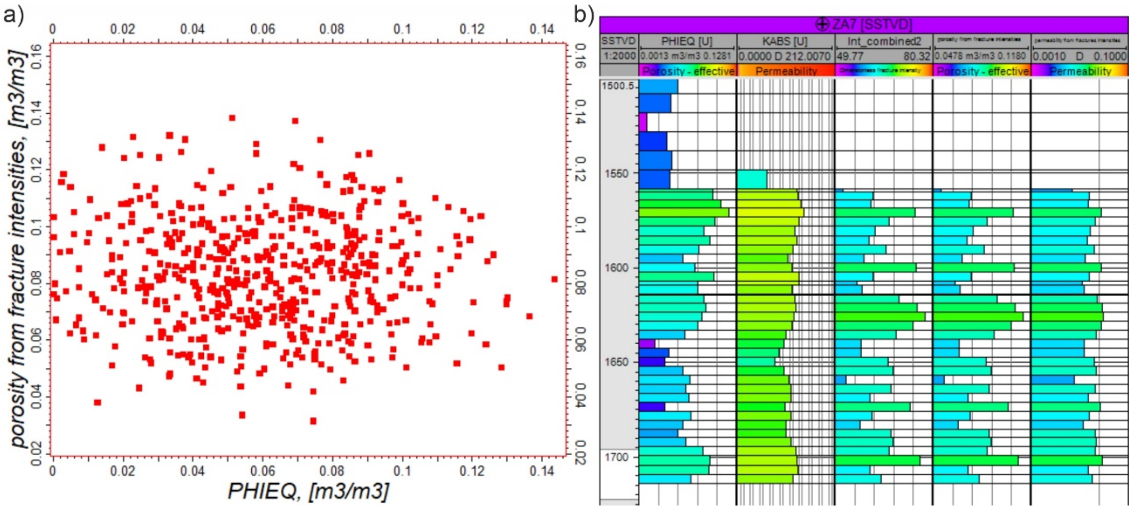

Fig. 2-6: Results of the fracture modeling procedure: a) cross-plot of porosities from fracture intensities and porosities from log data; b) an example of the resulting reservoir properties in Za7 well.

2.3 Summary

- Standard fracture modeling algorithm yields unwieldy numbers of fractures which are impossible to upscale into the grid causing crashes of Petrel.
- Simplified fracture modeling algorithm revealed problems with resulting upscaled reservoir properties. No suitable apertures can be estimated from the core material, because all cores are disintegrated. It was impossible to find fracture apertures yielding realistic porosities and permeabilities at the same time.
- An alternative approach was suggested using fracture intensities distribution and calibration formulas to calculate realistic values of reservoir properties based on correlation of fracture intensities and porosities and permeabilities respectively from well log data.

3 CONCLUSION

- FMS data show very small numbers of fractures in comparison with the 4 cores from Vranovice dolomite that are available. No correlation between the FMS fractures intensities (fracture density, i.e. number of fractures per length) and intensities observed in core material was found. No reasonable / statistically relevant coefficient could be used to increase the number of FMS fractures.
- Standard fracture modeling algorithms cannot produce either usable fracture model or unrealistic reservoir properties.
- An alternative fracture modeling algorithm was suggested, but it yields reservoir properties that do not correlate with the reservoir properties from log data analysis. There is then no way to decide which version of reservoir properties are closer to the truth.
- Based on the points made, **we suggest using reservoir properties from log data analysis**, because they proved to be realistic during previous iterations of dynamic modeling. However, it might be beneficial to try a dynamic modeling run with the reservoir properties calculated by the alternative algorithm, at least on the 25x25 m grid version (to save run time). If this test would show promising results, a full 10x10 m version could be run and the better match could be selected.

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