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'PULL UP' AND 'PUSH DOWN' EFFECTS IN SEISMIC REFLECTION: A USEFUL CONSTRAINT

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'Pull up' and 'push down' effects are commonly observed in seismic sections. These fictitious deformations of seismic reflections under local velocity anomalies can, if they are not identified, lead to misinterpretation of seismic sections. However, in some cases and using simplifying assumptions, these effects can provide a useful constraint in the estimation of the seismic velocities and therefore help interpretation in complex areas. Two examples are presented: the first displays a distinct 'pull up' effect related to the high seismic velocities associated with a salt diapir, the second shows a significant 'push down' effect related to the low velocity of sedimentary basins.

Keywords: seismic reflection, velocity anomalies, pull up, push down

1. Introduction

The 'pull up' and 'push down' effects, commonly observed in seismic sections, engender fictitious deformation of seismic reflections beneath a local anomaly of high or low velocity (*Fig. 1*). Such an anomaly may be related, for example, to salt diapirism, coral reefs, volcanic intrusions or young sedimentary basins, and has been known since the earlier development of reflection seismology. 'Pull up' and 'push down' effects can, usually, be recognized when they affect distinct and relatively flat underlying reflectors. The shape of the reflections in the seismic section follows the geometry of the high or low velocity anomalous body. A good knowledge of the seismic velocities is important in correcting such effects on the depth sections.

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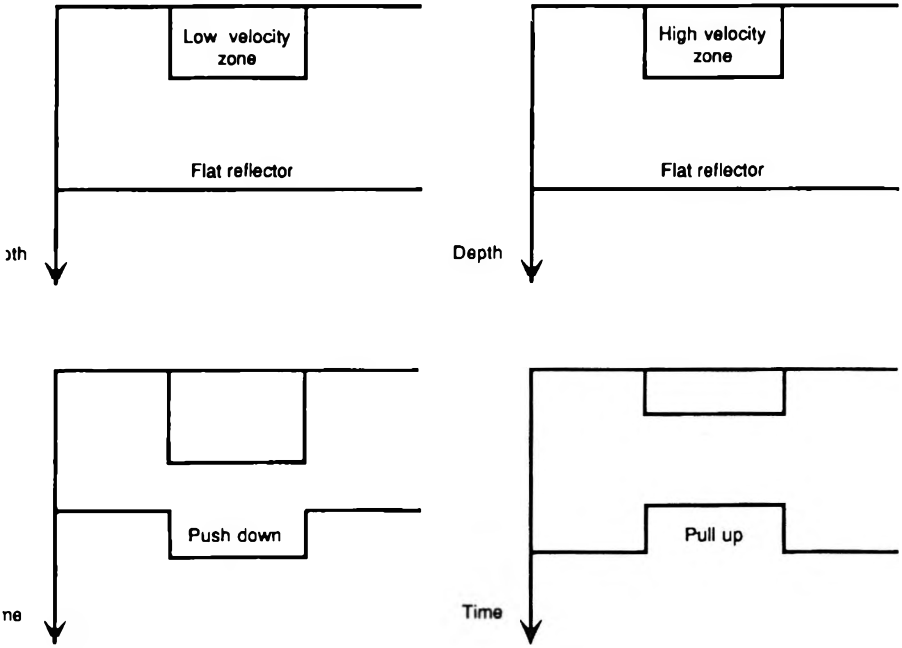


Fig. 1. 'Pull up' and 'push down' effects: a fictitious deformation of seismic reflectors under a local anomaly of velocity

1. ábra. Felboltozódási („pull up") és bemélyedési („push down") hatások: a szeizmikus reflektáló felületek helyi sebességanomáliák alatt létrejövő látszólagos deformációi

Рис. 1. Своды („pull up") и впадины („push down"): кажущиеся деформации сейсмических отражений в связи с локальными скоростными аномалиями

Nevertheless, 'pull up' and 'push down' effects are often considered as an inconvenience which can affect the interpretation of the seismic sections. In salt diapiric zones, for example, the seismic velocities are usually poorly defined and these effects, if not efficiently corrected on the depth sections, can be interpreted as geological features.

This paper intends to show that, in some cases and under simplifying assumptions, 'pull up' and 'push down' effects can provide a useful constraint in estimating the seismic velocities and, thus, help in interpreting complex areas. We present a simple method to perform this kind of analysis, and apply it to two examples. The first, taken from conventional exploration profiles, shows a study over a salt diapir. The second, from deep seismic reflection data, is used to obtain an estimation of the seismic velocity in the upper crust.

2. Modelling of 'pull up' and 'push down' effects: an approach to velocities

The conventional method used to interpret seismic reflection sections is based on two kinds of information: the time section itself, improved by more or less sophisticated processes, and the information on velocity, usually provided by the velocity analysis technique on multichannel experiments. On the basis of this information, one can migrate the section if required by the slope of the reflections and, finally, depth convert it. Nevertheless, problems may be encountered in the application of this method, particularly if the seismic velocities are poorly determined. The velocity analysis technique is not effective for areas which include strong velocity contrasts, numerous scatterers, dipping reflectors and/or complex geometrical patterns. Also, this technique cannot be employed for deep reflections because of the weak sensitivity of the CDP (common-depth-point) hyperbolae to the seismic velocity.

We propose a different way to help the interpretation of seismic sections in such difficult areas. This method, which is quite rough and can only provide an approximation of the seismic velocities, is based on the observation of 'pull up' and/or 'push down' effects on underlying reflections. Such 'pull up' or 'push down' effects, related to high or low velocity anomalies, are often observed in areas where velocity analyses are not suitable. The method consists of an a priori assumption of the geometry of the underlying reflectors, from geological evidence and/or analysis of the data which are not affected by the 'pull up' or 'push down' effect. Such an a priori assumption leads to the calculation, at several locations, of estimated velocities in the anomalous body using the classical relation

$$\textit{Interval velocity} = 2 * \textit{Thickness} / \textit{Interval vertical time}$$

Such a formulation is valid only in the case of a relatively simple a priori assumption on the geometry of the anomalous body and underlying reflectors. A more accurate formulation, which is not required in the following examples, should take into account the effect of more complex geometry on the ray paths. The geological plausibility of the resulting velocities governs the acceptance or rejection of the a priori assumption. Realistic velocities a posteriori confirm the validity of the model, while unrealistic velocities lead to its rejection.

In order to check the applicability of such a method, we analysed the sensitivity of the result (the velocity) to variations of the input parameters (the thickness). A too high sensitivity means a weak probability of obtaining reasonable velocity values, even with a correct geometrical model; a too low sensitivity could lead to plausible velocity values, even with a false model. We included uncertainties on the interval time measurements in the calculations. In the following examples, we obtain a 30% variation (1.2 km/s) for the interval velocity in the diapir assuming a 20% variation (0.4 km) for the thickness of the diapir. We also obtain a 23% variation (1.38 km/s) for the velocity of the upper crust assuming a 20% variation (5 km) for the lower crustal reflectors. The calculations suppose an uncertainty on the time measurement which reaches 0.05 s. Thus, the sensitivity analysis shows that significant variations of the geometrical model lead to departures of the velocities beyond the range of plausible values, and demonstrates the applicability of the method. The two examples mentioned above present applications of this method to a ‘pull up’ effect observed beneath a salt diapir and ‘push down’ effects observed beneath sedimentary basins.

3. Lateral variations of the seismic velocity in a salt diapir

We have used well data and conventional seismic profiles to study a 20 km^2 area in the southern Rhine Graben (France), at the northern border of the Mulhouse potassic salt mine district. These data (*Fig. 2*) show a thick Tertiary sequence underlain by Jurassic sediments. A Bajocian-Bathonian oolithic limestone, known as the ‘Grande Oolithe’, is particularly clear from the seismic data (*Fig. 3*) and closely underlies a major discordance, corresponding to Upper Jurassic and Cretaceous [MDPA 1983]. This discordance, known from the well data, is not associated with a pronounced angular discontinuity and probably corresponds to a hiatus of deposition rather than to a tectonically related erosion. The evaporitic layers were deposited at Sannoisian and are related to the Oligocene subsidence of the Rhine Graben [BLANC-VALLERON, GANNAT 1985]. This subsidence continued during the Upper Oligocene, leading to the deposition of detritic Stampian and Chattian sediments. Diapirism occurred during and after the late Oligocene and roughly followed the N-S orientation of the Rhine Graben normal faults [LARROQUE, ANSART 1985].

Figure 3 displays a seismic section in this area. The strong reflection (noted ‘*O*’) close to the base of the diapir corresponds to the top of the ‘Grande Oolithe’ layer, as evidenced by the well data. The other marked reflection (‘*T*’) represents the top of the diapir. The complex seismic pattern observed in the diapir is a typical characteristic of salt diapirs [see for example NELY 1980, JENYON 1986]. We note that reflection *O* seems to reflect the shape of the diapir itself. A similar observation can be made from other profiles across the diapir. We suggest that the observed shape of reflection *O* is related to a ‘pull up’ effect due to the high seismic velocity in the salt.

Using velocity analyses at several locations along the profiles we calculated, using the DIX [1955] formula, the approximate interval velocities of the near surface layer (from surface to reflector *T*) and of the diapir (between reflectors *T* and *O*) at each location. The resulting interval velocities of the diapir range between 3.0 and 6.0 km/s. We find no relation between these velocities and the thickness of the diapir (*Fig. 4a*). This large dispersion of the interval velocities may be related to the poor suitability of the classical velocity

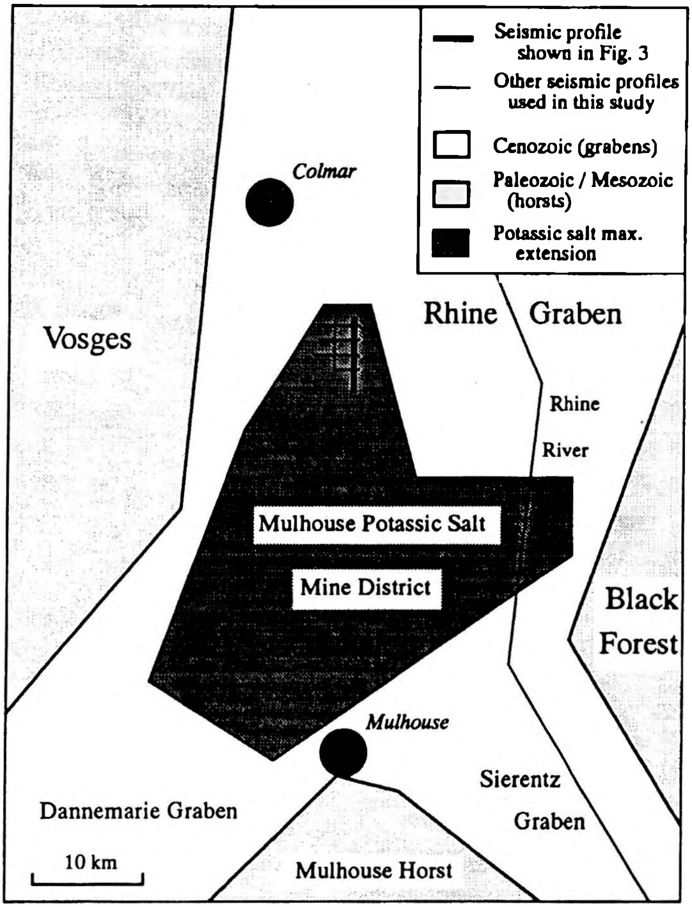


Fig. 2. Location of the area studied on the northern border of the Mulhouse potassic district, southern Rhine Graben, France. The profile displayed in Fig. 3 is underlined

2. ábra. A vizsgált terület elhelyezkedése a franciaországi Rajna-árok déli részén található Mulhouse kálisóbánya északi határán. A 3. ábrán látható szelvényt vastag vonal jelzi

Рис. 2. Исследуемый участок расположен на северной границе месторождения калиевой соли Мюлхоус в южной части Рейнского грабена во Франции. Жирная линия показывает расположение профиля, изображенного на Рис. 3

analysis in diapiric areas, due to strong velocity contrasts, large dips and numerous scatterers in the salt [CORDIER 1983].

Thus, we have tried to use the 'pull up' effect observed on reflection *O* to determine the interval velocities of the diapiric sequence. We assumed that the previously found interval velocities of the near surface sequence are good and used them to calculate the depth of reflector *T*. Next, we assumed that reflector *O* is roughly flat (*Fig. 5*) and we used this hypothetical depth section and the observed time section to compute the interval velocities in the diapir.

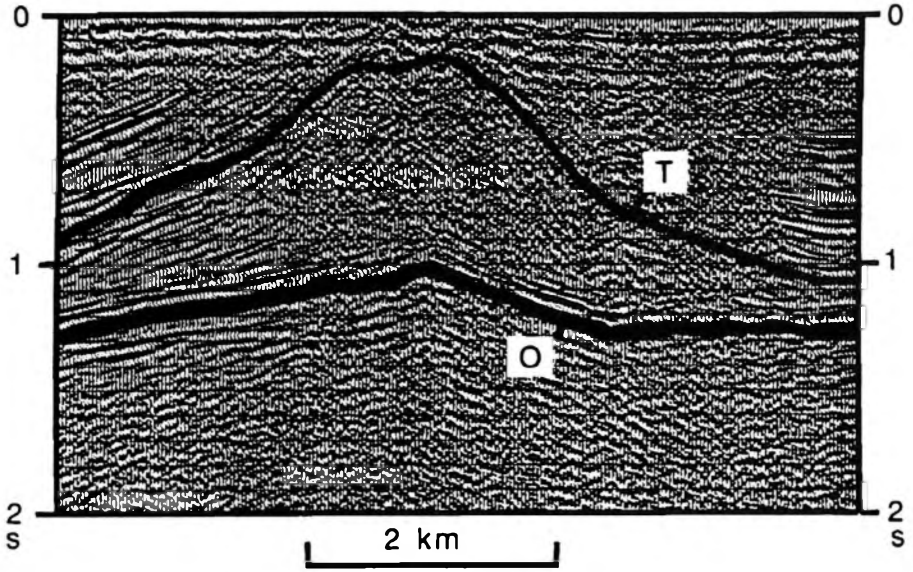


Fig. 3. Typical example of 'pull up' beneath a salt diapir observed in the southern Rhine Graben, France; *T* is the top of the diapir, *O* is the reflection on the 'Grande Oolithe' limestone, which marks the base of the diapir

3. ábra. Tipikus példa só diapír alatti látszólagos felboltozódásra („pull up") a Rajna-árok déli részéről, Franciaországból; *T* a diapír teteje, *O* a „Grande Oolithe" mészkőről érkező reflexió, amely a diapír alját jelöli

Рис. 3. Типичный пример кажущегося свода под соляным диапиром в южной части Рейнского грабена (Франция). *T* кровля диапира, *O* отражения с известняковой формации „Гран Оолит", указывающие подошву диапира

Several observations support the hypothesis of a roughly flat reflector *O*. First, the 'Grande Oolithe' limestone is a very compact layer and cannot be deformed easily. Thus, we expect that it will undergo brittle deformation and faulting rather than form a fold as indicated by the seismic section if the 'pull up' effect is not assumed. In addition, such a fold is not likely in the Rhine Graben considering the overall extension in this area. The flatness of reflector *O* seems consistent with the available geological data. In the areas around the diapir, reflector *O* appears roughly flat. Based on a well and some velocity analysis from non diapiric zones, we determined its depth to be 2075 m.

Using D_O as the depth of reflector *O* (2075 m), D_T as the depth of reflector *T* determined from the velocity analyses, t_O as the two way travel time from surface to reflection *O*, and t_T as the two way travel time from surface to reflection *T*, we obtain the relation

$$V_{T\text{-}O} = 2\,(D_O - D_T)\,/(t_O - t_T)$$

where $V_{T\text{-}O}$ is the interval velocity in the diapir. This relation was used to calculate an alternative interval velocity at each location.

Such calculation provides interval velocities in the diapir which range between 2.5 and 5.0 km/s. These values are, most probably, more reasonable than the previous values using conventional analysis. Salt velocities usually range between 4.0 and 5.0 km/s [CORDIER 1983]. The diapir consists of salt, but probably also includes marl and clay which have lower seismic velocities. Moreover, when the interval velocities versus the double travel time between reflections T and O are plotted, a linear relation is obtained (*Fig. 4b*). This velocity function indicates higher seismic velocities in the thick part of the diapir than in the flanks. The averaged velocity in the thickest parts of the diapir is 4.0 km/s, which is almost the pure salt velocity, 3.5 km/s in the flanks, and only 3.0 km/s in the thinnest parts of the salt layers. This result is consistent with the classical models of salt migration [e.g. JENYON 1986]. Layers mainly

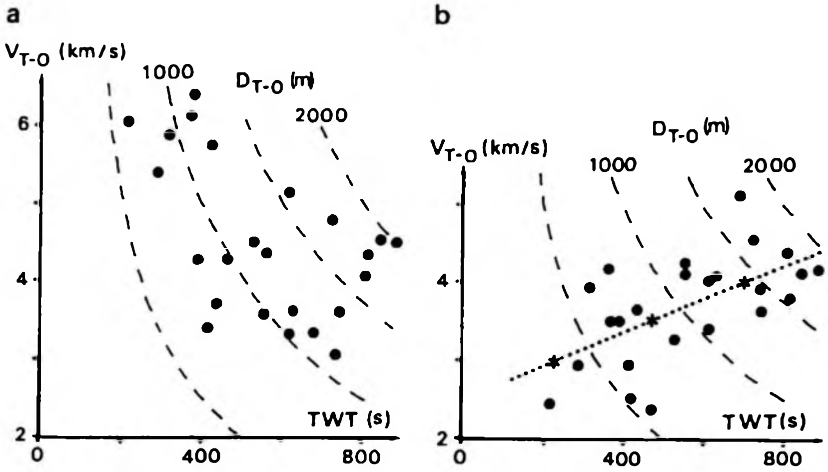


Fig. 4. Velocity versus two way travel time in the diapiric sequence: a) from velocity analysis; b) using the 'pull up' effect. TWT is the two way travel time between T and O, $V_{T\text{-}O}$ the interval velocity of the sequence T-O, and $D_{T\text{-}O}$ the thickness of this sequence. A lateral velocity function can only be derived from b), due to the important dispersion in a)

4. ábra. A kétszeres menetidő-sebesség függvény a diapír rétegsorban: a) sebességanalízisből, b) a „pull up" jelenség felhasználásával. TWT a T és az O közötti kétszeres terjedési idő, $V_{T\text{-}O}$ a T-O rétegsor intervallumsebessége, a $D_{T\text{-}O}$ pedig a rétegsor vastagsága. Laterális sebességfüggvényt csak a b) alapján tudunk számítani, mivel az a)-n igen nagy a szórás

Рис. 4. Функция двойное время-скорость внутри диапира a) по анализу скоростей, b) при использовании явления „pull up". TWT двойное время хода между поверхностями T и O, $V_{T\text{-}O}$ скорость интервала T-O, $D_{T\text{-}O}$ мощность интервала T-O. Латеральная скоростная функция была определена лишь в случае b), в связи с большой дисперсией данных в случае a)

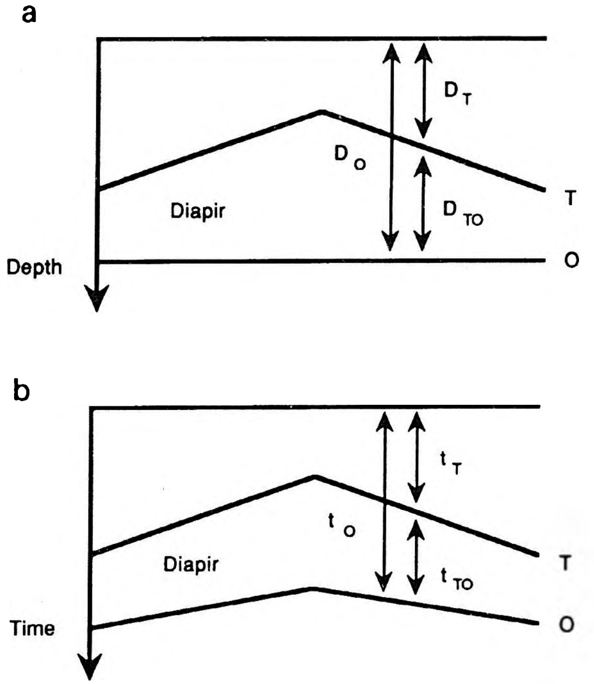


Fig. 5. a) A priori assumption about the reflector geometry. Reflector *T* is depth converted using velocities given by velocity analysis. Reflector *O* is assumed flat from geological evidence; b) corresponding seismic section

5. ábra. a) A reflektor geometriájára vonatkozó a priori feltételezés. A *T* reflektor mélység-konvertálását a sebességanalizisből számolt sebeségekkel végeztük. Az *O* reflektort földtani megfontolások alapján síknak vettük; b) a megfelelő szeizmikus szelvény

Рис. 5. а) A priori предположение о геометрии отражающего горизонта. Определение горизонта *T* выполнено по скоростям, определенным анализом скорости. Горизонт *O* считается горизонтальным по геологическим соображениям; b) соответствующий сейсмический разрез

composed of massive and pure salt flow laterally and accumulate in dome structures. On the contrary, layers composed of melted salt, clay and/or marl remain in the flanks. Consequently, the seismic velocities in the diapir reach the velocity of the pure salt while the flanks show lower velocities.

4. Estimation of the seismic velocities in the crust

A second example demonstrating the use of ‘pull up’ and ‘push down’ effects is drawn from deep seismic reflection data. The SWAT (South Western Approaches Traverse) profiles were acquired in the Celtic Sea-Western Channel area by the BIRPS and ECORS groups in 1983 [BIRPS-ECORS 1986].

The 15 seconds (TWT) records allow the examination of the entire crust in this area [e.g. DYMENT 1989]. Two important Mesozoic and Cenozoic sedimentary basins, the deep North Celtic Sea Basin and the shallower South Celtic Sea Basin, can be observed on the sections of SWAT 2 to 5 profiles (*Fig. 6*). Strong dipping reflectors interpreted as Variscan thrusts [BIRPS-ECORS 1986] cross the nearly transparent upper crust. As generally observed in Western Europe, this upper crust is underlain by a very reflective lower crust [MEISSNER, WEVER 1986; MATTHEWS, CHEADLE 1986; BOIS et al.1987]. Wide-angle seismic experiments in neighbouring areas [MOONEY, BROCHER 1987] determine the Moho to be at the base of the reflective unit. In contrast, the upper mantle is nearly transparent.

A problem encountered in deep seismic reflection studies is that of determining the crustal velocities. Velocity analysis is usually effective in the sedimentary section only, but cannot be used to study the velocity distribution of the deeper parts of the crust because of the flatness of the CDP hyperbolae. Wide-angle experiments (for example ESP) are most probably the best way to calculate accurate velocities in the deep crust, despite possible biases related to seismic anisotropy and inhomogeneous plane wave nature. Nevertheless, such data are not available in the Celtic Sea area. To overcome this problem, BANO

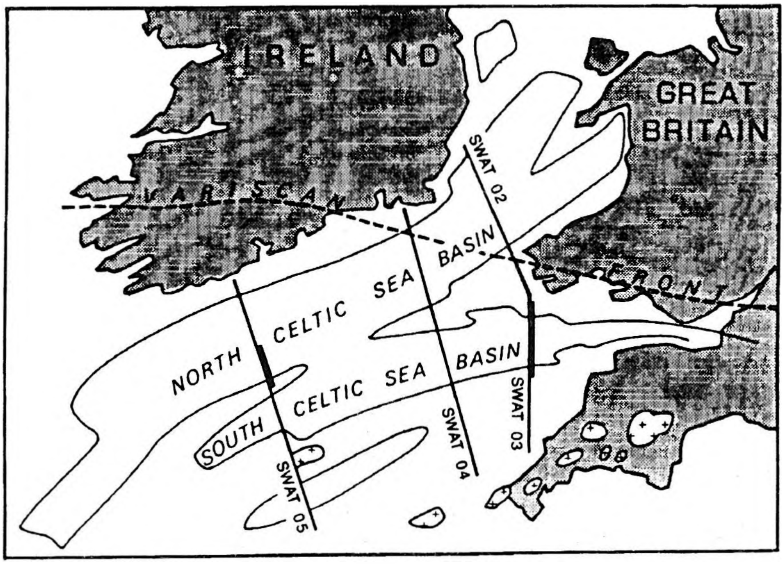


Fig. 6. Location of the SWAT profiles in the Celtic Sea area. The Variscan Front, North and South Celtic Sea Basins and Cornwall batholiths are also shown. Parts of the profiles displayed in Figs. 8 and 9 are underlined

6. ábra. A SWAT szelvények elhelyezkedése a Kelta-tenger területén. A variszkuszi frontot, az Észak- és Dél-Kelta-tenger medencéit és a Cornwall batolitokat szintén feltüntettük. A 8. és 9. ábrákon bemutatott szelvényrészletek helyét vastag vonallal jelöltük

Рис. 6. Расположение профилей SWAT на участке Келтийского моря. На карте также приведены расположения варисского фронта, бассейны Северо- и Южно-Келтийских морей и батолитов Корнуалла. Жирными линиями отмечены интервалы профилей,

[1989] and DYMENT, BANO [1991] modelled diffraction hyperbolae of short flat reflectors in complex parts of the lower crust. Having applied this method to a part of the SWAT 5 profile, they explain the complex patterns of reflections observed on this section. They also obtain, adjusting the RMS velocity to the observed hyperbolae, a crustal RMS velocity estimation of 6 km/s. We propose here another approach to obtain upper crustal velocities using the 'push down' effect of sedimentary basins.

A characteristic feature observed on the SWAT data is the rough flatness and relatively constant thickness of the reflective lower crust [DYMENT 1989; DYMENT et al. 1990; SIBUET et al. 1990]. The constant thickness appears to characterize the whole area. The flatness is particularly evidenced in areas where the sedimentary basins are not present. WARNER [1987] suggested that no velocity 'push down' is observed beneath the deep sedimentary basins. He explained this observation by the opposing effects of local isostasy and velocity: the velocity 'push down' would be compensated by an isostatic uplift of the Moho. However, careful analysis of the Moho and lower crustal reflections beneath the sedimentary basins reveals more complex patterns.

Bano's automatic extraction of reflections [BANO et al. 1988; BANO 1989] was applied to the SWAT 2 to 5 profiles (Figs. 8 and 9), to increase the quality of the analysed sections. Undulations of the Moho and lower crust reflections were evidenced on the resulting time sections, with a marked correlation with the younger, mainly Cretaceous and Cenozoic, sedimentary basins. The similar shape of these seismic reflections suggests a 'push down' effect of the low velocity sedimentary basins on the presumably flat underlying lower crustal reflections. Velocity analyses confirm that the velocities of the sedimentary basins are lower than those of the surrounding areas.

In order to verify the hypothesis of a 'push down' effect of the sedimentary basins on a physically flat lower crust (*Fig. 7)* and to estimate upper crustal velocities, we analysed two areas where the lower crust reflections are quite continuous and their undulations well marked. The first (*Fig. 8*), from the SWAT 5 profile, shows a narrow sub-basin of the North Celtic Sea Basin (Fig. 6), mainly filled by Cretaceous sediments [DYMENT 1989]. The other (*Fig. 9*), from the SWAT 3 profile, shows the South Celtic Sea Basin-Bristol Channel Basin junction (Fig. 6).

In both examples, we marked some strong and continuous crustal reflections (Figs. 8 and 9). The sedimentary velocities are determined from the velocity analysis. Using, at location *i*, D_s^i as the depth of the sediments, t_s^i as the two way travel time to the basement and t_c^i as the two way travel time to an assumed flat crustal reflection, we obtain the relation

$$V_c^{ij} = 2\,(D_s^{\,i} - D_s^{\,j}) \,/ [(t_s^{\,i} - t_s^{\,j}) - (t_c^{\,i} - t_c^{\,j})]$$

where V_c^{ij} is the velocity of the upper crust between the top of the basement and the maximum depth of the sedimentary basin D_s^{max}, considered to be uniform between locations *i* and *j*.

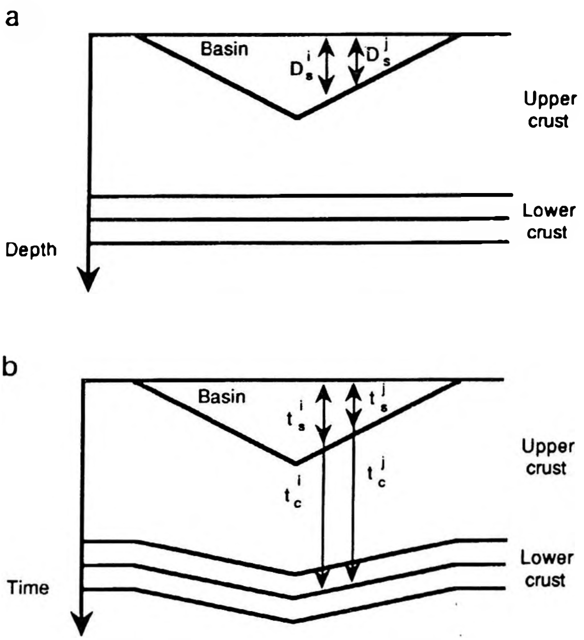


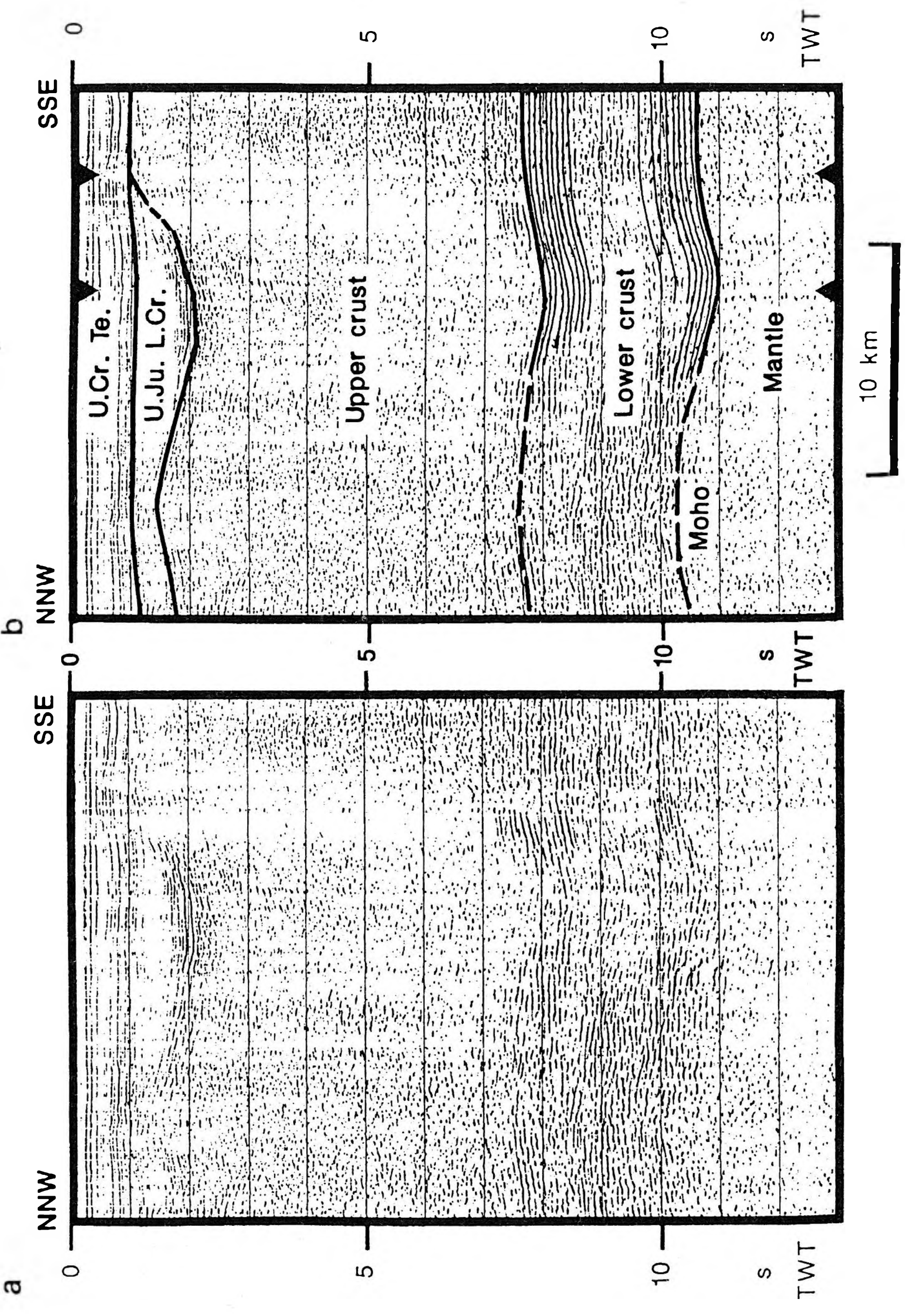
Fig. 7. a) A priori assumption about the reflector geometry. The basin is depth converted using velocity analysis. The lower crustal reflectors are assumed flat (see text); b) corresponding seismic section

7. ábra. a) A reflektor geometriájára vonatkozó a priori feltételezés. A medence mélység-konvertálását a sebességanalízis alapján végeztük. Az alsókéregbeli reflektáló felületeket vízszintesnek vettük (lásd a szöveges részt); b) a megfelelő szeizmikus szelvény

Рис. 7. а) A priori предположение о геометрии отражающего горизонта. Определение глубины бассейна выполнено по данным анализа скоростей. Отражающие горизонты, расположенные в нижней коре, считаются горизонтальными (см. текстовую часть); b) соответствующий сейсмический разрез

The main limitation of this method is its relatively high sensitivity to the measured times. The differences $(t_s^i - t_s^j)$ and $(t_c^i - t_c^j)$ are usually quite small and represent only a few times the uncertainty in their measurement. The uncertainty in the velocity can reach 23 per cent of its value. In order to reduce the inherent uncertainty, we applied the method to several different locations and reflections. We obtained an average upper crustal velocity of 6.16 km/s on SWAT 5, and 6.20 km/s on SWAT 3. The standard deviation of the computed values is only 0.2 km/s.

The estimates of the upper crustal velocities that we derived are in good agreement with the one found by BANO [1989] and DYMENT and BANO [1991] from diffraction modelling on the southern part of the SWAT 5 profile. In neighbouring areas, refraction and ESP experiments provided crustal velocities of 6.2 km/s in the North Sea [KLEMPERER 1988] and 5.9 to 6.2 km/s for the upper crust in the Bay of Biscay [PINET et al. 1987]. The values determined using the 'push down' effect are consistent with these results and confirm in some way the assumption of flat geometry for the lower crustal reflections and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Upper crust
Lower crust
Moho
Mantle
10 km

the Moho under the Celtic Sea basins. This result may have important consequences on the still unknown nature and origin of the lower crustal reflectivity, and may help to discriminate among the numerous existing models [e.g. DYMENT, BANO 1991].

5. Conclusion

In some cases and under simple assumptions, 'pull up' and 'push down' effects can provide a useful constraint to the knowledge of seismic velocities and the interpretation of seismic sections in complex areas, as illustrated by the previous examples. The poor suitability of velocity analysis in complex areas such as diapirs, reefs or volcanic intrusions makes difficult the determination of accurate velocities and thus the depth conversion of time sections in these areas. A simple a priori assumption about the geometry of underlying reflectors is used as a basis for calculating interval velocities in the anomalous body. The geological plausibility of the computed velocities a posteriori confirms or negates the assumption about the geometry.

Application of this method to the first example gives additional information on the velocities in a salt diapir, and thus on the salt migration processes. The second example provides an estimate of the upper crustal velocity in the Celtic Sea area, and confirms in some way the flat character of the lower crustal reflectors in this area, which is related to the still controversial nature and origin of the lower crustal reflectivity. Such results demonstrate the applicability of the method despite (and perhaps because of) its quite simplistic background.

Fig. 8. Part of the deep seismic reflection profile SWAT 5, showing the reflective lower crust affected by 'push down' effect of the southernmost part of the North Celtic Sea basin. a) the data after automatic extraction of reflections; b) the same, interpreted. Crustal velocities are calculated for the underlined lower crustal reflections at the locations marked by black triangles. U and L for upper and lower, Tr, Ju, Cr and Te for Triassic, Jurassic, Cretaceous and Tertiary

8. ábra. A SWAT 5 mély szeizmikus reflexiós szelvény egy részlete, amely az Észak-Kelta-tenger medencéjének legdélibb része okozta „push down" jelenség által érintett alsó kéregbeli reflektáló felületet mutatja. a) az adatok az automatikus reflexiókiemelési művelet után; b) ugyanez értelmezve. A kiemelt kéregbeli reflexiókra vonatkozó sebességeket a fekete háromszögekkel jelölt helyeken számítottuk. Az U felsőt, az L alsót, a Tr, Ju, Cr, és Te pedig triászt, jurát, krétát és negyedidőszakot jelöl

Рис. 8. Интервал глубинного сейсмического разреза SWAT 5, указывающий отражающий горизонт в нижней коре, затронутый влиянием „push down" от южной части бассейна Северо-Келтийского моря. а) данные после автоматического выделения отражений, b) то же самое с интерпретацией. Расчет скоростей для выделенных горизонтов выполнен по точкам, обазначенным черными треугольниками. U означает верхний, L нижний, а Tr, Ju, Cr, и Te триасовый, юрский, меловой и третичный возраст соответственно

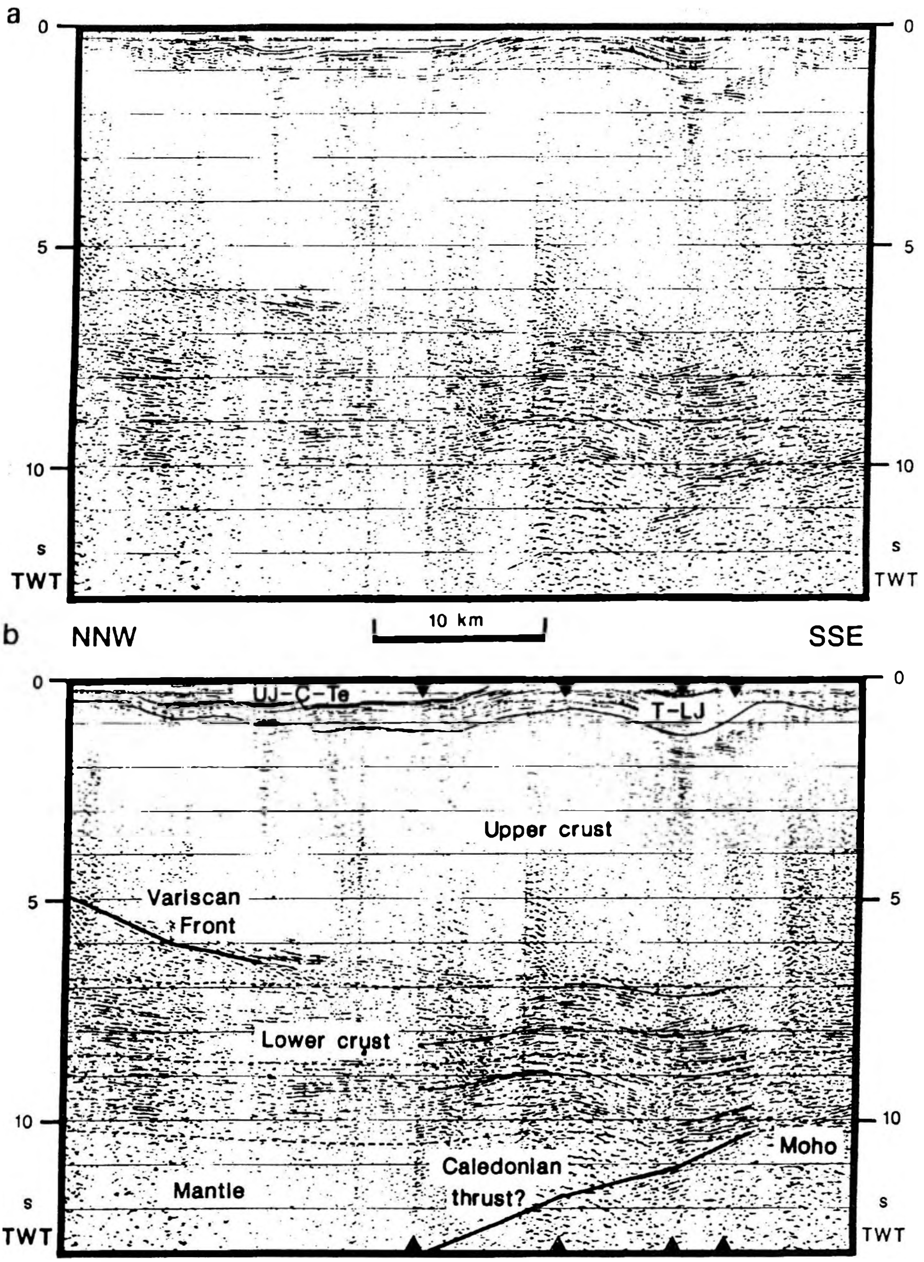
a
0
5
10
s
TWT
0
5
10
s
TWT
b
NNW
10 km
SSE
0
UJ-C-Te
T-LJ
Upper crust
5
Variscan
Front
Lower crust
10
Moho
Caledonian
thrust?
Mantle
s
TWT
0
5
10
s
TWT

Fig. 9. Part of the SWAT 3 profile, showing the reflective lower crust affected by 'push down' effect of the South Celtic Sea and Bristol Channel basins. a), b) see Fig. 8. Dotted lines are time converted reflections of flat reflectors, assuming a crustal velocity of 6.2 km/s. Note the 'push down' effect on the Variscan Front and on a presumed Caledonian thrust

9. ábra. A SWAT 3 szelvény egy része; az alsó kéregbeli reflektáló felületen a Dél-Kelta-tenger és a Bristol csatorna medencéi által keltett „push down" jelenség látszik. a) és b) mint a 8. ábrán. A pontozott vonalak sík reflektáló felületek időkonvertált reflexiói, 6,2 km/s-os kéregbeli sebességet feltételezve. Figyeljük meg a „push down" hatást a variszkuszi fronton és a feltételezett kaledoniai törésen

Рис. 9. Интервал профиля SWAT 3; по отражающему горизонту в нижней коре отмечается влияние „push down", вызванное бассейнами Южно-Келтийского моря и Бристольского канала. a) и b) как на Рис. 8. Пунктиром обозначены пересчитанные на время отражения от горизонтальных отражающих горизонтов, при предположении скорости 6.2 км/с внутри коры.Обращается внимание на влияние „push down" на варисском фронте и на предпологаемом каледонском разломе

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LÁTSZÓLAGOS FELBOLTOZÓDÁSOK („PULL UP") ÉS BEMÉLYEDÉSEK („PUSH DOWN") A SZEIZMIKUS REFLEXIÓKBAN— SEGÍTSÉG AZ ÉRTELMEZÉSBEN

Jérôme DYMENT és Maksim BANO

A szeizmikus időszelvényeken gyakran megfigyelhetünk felboltozódásokat és bemélyedéseket. A szeizmikus reflexióknak ezek a helyi sebességanomáliák alatt létrejövő látszólagos deformációi, ha nem azonosítjuk őket, akkor a szeizmikus szelvény félreértelmezéséhez vezethetnek. Mindamellett bizonyos esetekben, egyszerűsítő feltevéseket használva ezek a hatások hasznos megszorítást jelenthetnek a szeizmikus sebességekre vonatkozóan és így segíthetnek komplex területek értelmezésénél. Két példát mutatunk be: az első egy nagy szeizmikus sebességű só diapírhez kapcsolódó határozott látszólagos felboltozódási hatást mutat be, a második egy kissebességű üledékes medencéhez kötődő látszólagos bemélyedést ábrázol.

КАЖУЩИЕСЯ СВОДЫ („PULL UP") И ВПАДИНЫ („PUSH DOWN") СЕЙСМИЧЕСКИХ ОТРАЖЕНИЙ: ПОЛЕЗНЫЕ НЕДОСТАТКИ

Жером ДИМЕН и Максим БАНО

На сейсмических временных разрезах часто наблюдаются своды и впадины. Кажущиеся деформации сейсмических отражений связаны с локальными скоростными аномалиями и могут привести к ложной интерпретации разреза, если их характер не выявлен. Тем не менее, подобные явления могут служить полезной информацией о скорости сейсмических волн и способствуют комплексной интерпретации участков. Показаны два примера: на первом наблюдается кажущийся свод, связанный с высокоскоростной соляной диапировой структурой, а на — втором кажущаяся впадина, связанная с низкоскоростной аномалией осадочного бассейна.