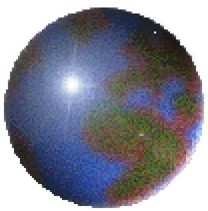
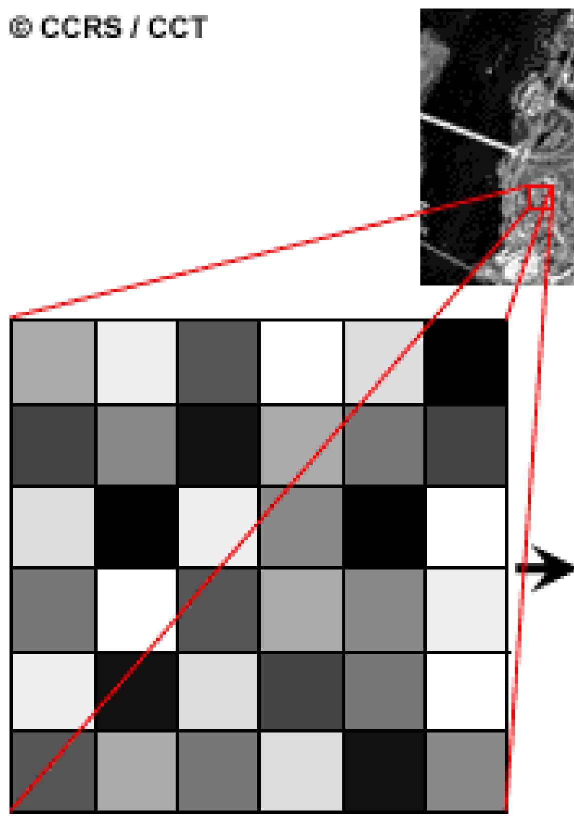


GIS a DPZ v geologii

Analýza snímků/obrazu

Karel Martínek

snímky



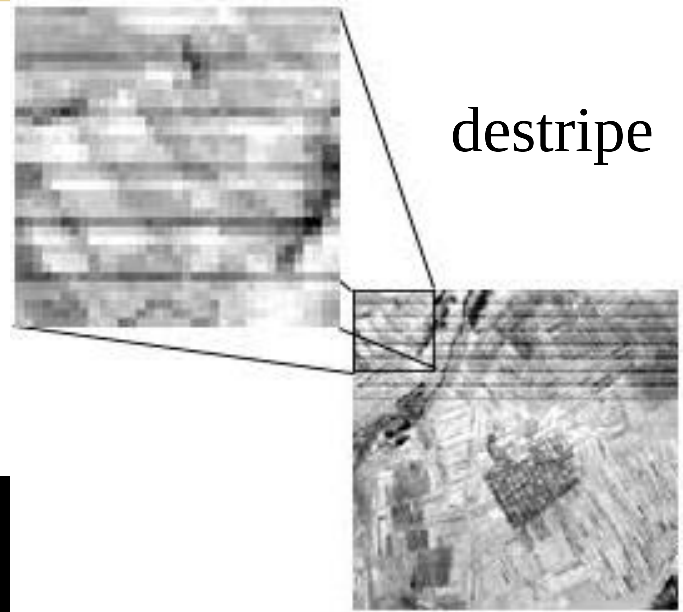
170	238	85	255	221	0
68	136	17	170	119	68
221	0	238	136	0	255
119	255	85	170	136	238
238	17	221	68	119	255
85	170	119	221	17	136

analýza snímků

- vizuální interpretace
- digitální zpracování obrazu
  - preprocessing (radiometrické a geometrické korekce, ...)
  - vylepšení snímku (úpravy kontrastu, prostorové filtrování, ...)
  - transformace snímku (podíly pásem, analýza hlavní komponenty, ...)
  - klasifikace (neřízená, řízená)

preprocessing

radiometrické korekce



destripe

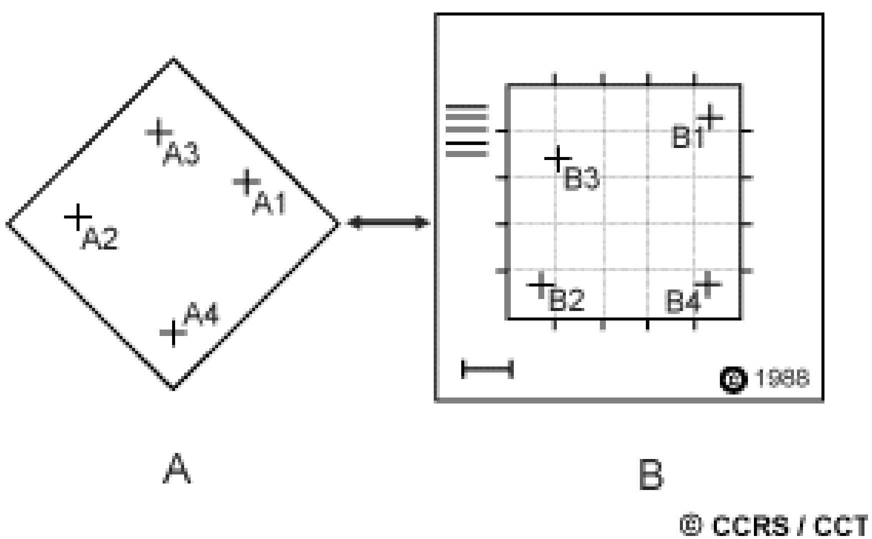
mosaikování

replace bad lines

atmosférické korekce

Rektifikace (geometrická korekce, geometrická registrace, georeferencování)

- originální data obsahují velké polohové chyby – nelze je užít jako mapy
- účelem korekce je vyloučit zkreslení tak, aby bylo možno snímek vlícovat do mapy
- georeferenční korekce se provádí pomocí **vlícovacích bodů** – body, které lze přesně lokalizovat na rastru (snímku) a jsou známy jejich mapové souřadnice



- nová poloha se počítá pomocí transformační rovnice: polynom 1. řádu (pouze translace, rotace, změna velikosti; nejméně 3 vl. body), polynom 2. řádu (6 bodů), 3. řádu (10 bodů), ...
- v případě polynomů vyšších řádů lze získat lepší shodu pro body blízké vlícovacím bodům, ale tam, kde body chybí, se vyskytnou větší chyby

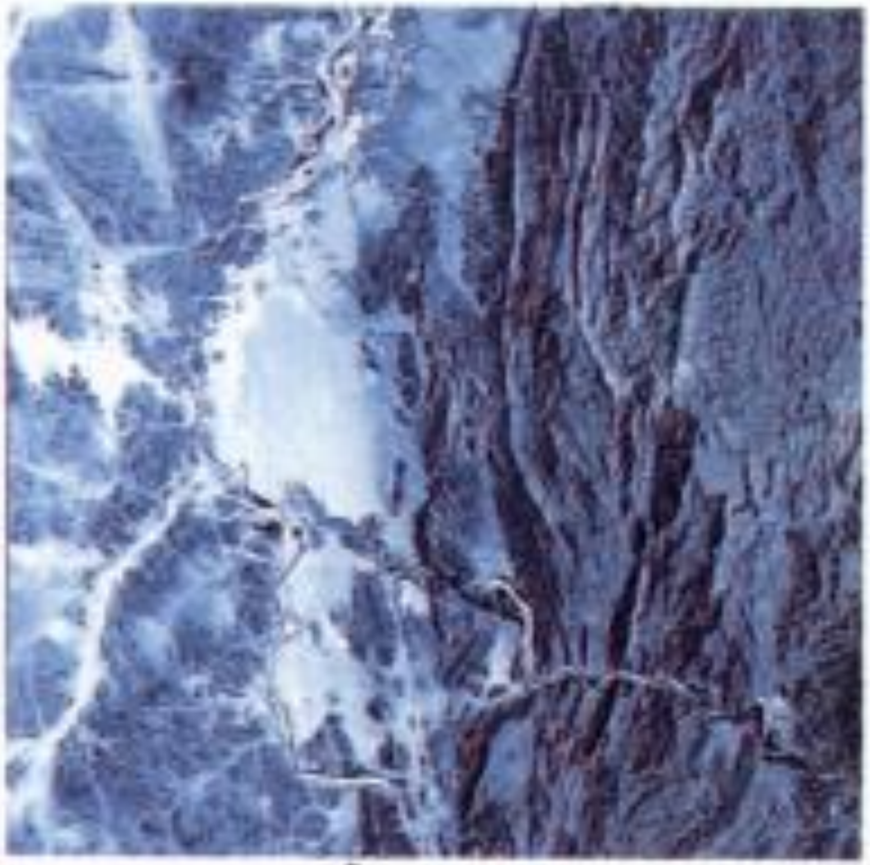
- transformační fce najde správnou polohu, pak dojde k **převzorkování**, zde je nutno najít vhodnou hodnotu buňky; 3 metody:
  - **metoda nejbližšího souseda** (*nearest neighbor*), hodnota buňky se převezme z nejbližšího souseda; vhodné pro diskrétní data (tematické mapy)
  - **bilineární interpolace** (*bilinear interpolation*) – vážený průměr (vzdáleností) čtyř nejbližších buněk; výstup může být lokálně nespojitý (snímky)
  - **kubická konvoluce** (*cubic convolution*) – výpočet ze 16 nejbližších buněk; spojitý výstup, méně ostrý (snímky)

Praktické cvičení - rektifikace

- rektifikujte naskenovanou topografickou mapu do systému S-JTSK Křovák
- nástroje: Georeferencing (ArcView)
- postup:
  - umístění vlícovacích bodů
  - kontrola chyb
  - převzorkování (*rectify*)

kombinace spektrálních pásem

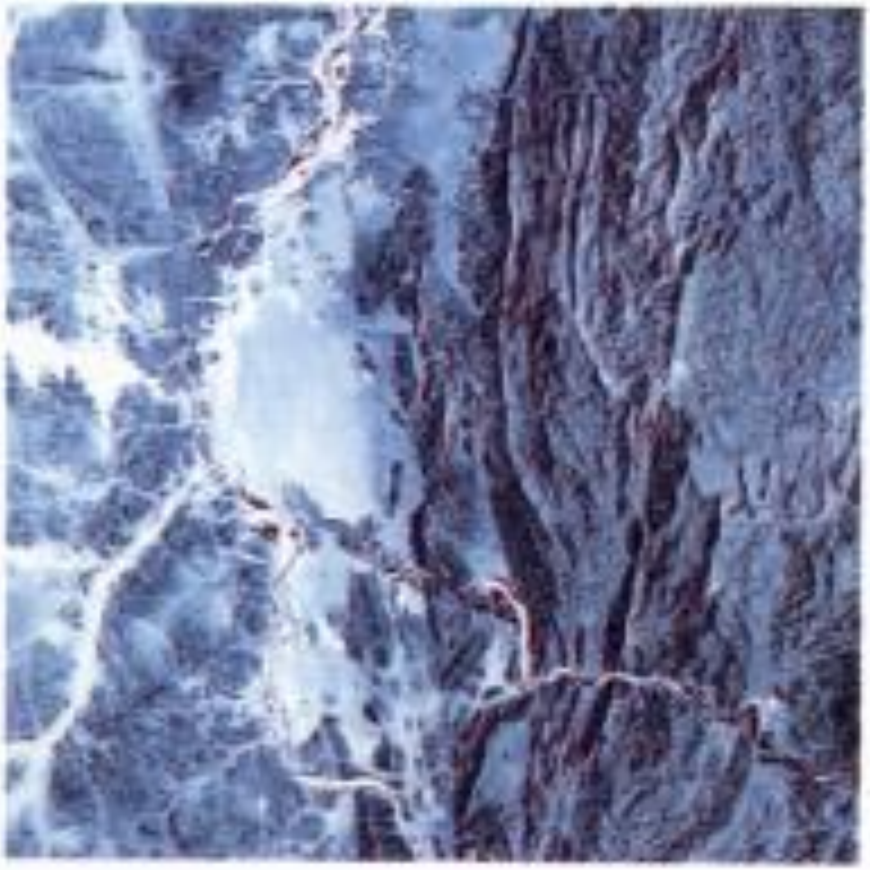
(a)



TM 321 RGB

Figure 5.10 These linearly stretched false-colour Landsat TM images of part of the Sudan–Eritrea border are of the area shown in Figures 5.4 to 5.9. They reveal more details than the band 3 images in both light and dark terrains, but each band combination contains different information. The natural colour image (bands 3, 2 and 1 as RGB) (a) is least informative. The standard false-colour composite (bands 4, 3 and 2 as RGB) (b) shows vegetation in shades of red, but little more than (a). Combining bands 5, 3 and 1 in RGB (c) reveals better detail of the distribution of different rock types, while suppressing vegetation as dark tones. The importance of a correct assignment of bands to colour components is shown by (d), which has bands 3, 1 and 5 in RGB. Exactly the same information as in (c) is shown, but the choice of colours prevents the eye from appreciating the full range of variability. The geology is of a major boundary between a high-grade metamorphic terrain with granite intrusions and basaltic dykes to the left, and a very complex, younger terrain of peridotites, metabasalts and metasediments to the right. The boundary is marked by deep alluvium along a major river controlled by a huge shear zone. Each image is 30 km across.

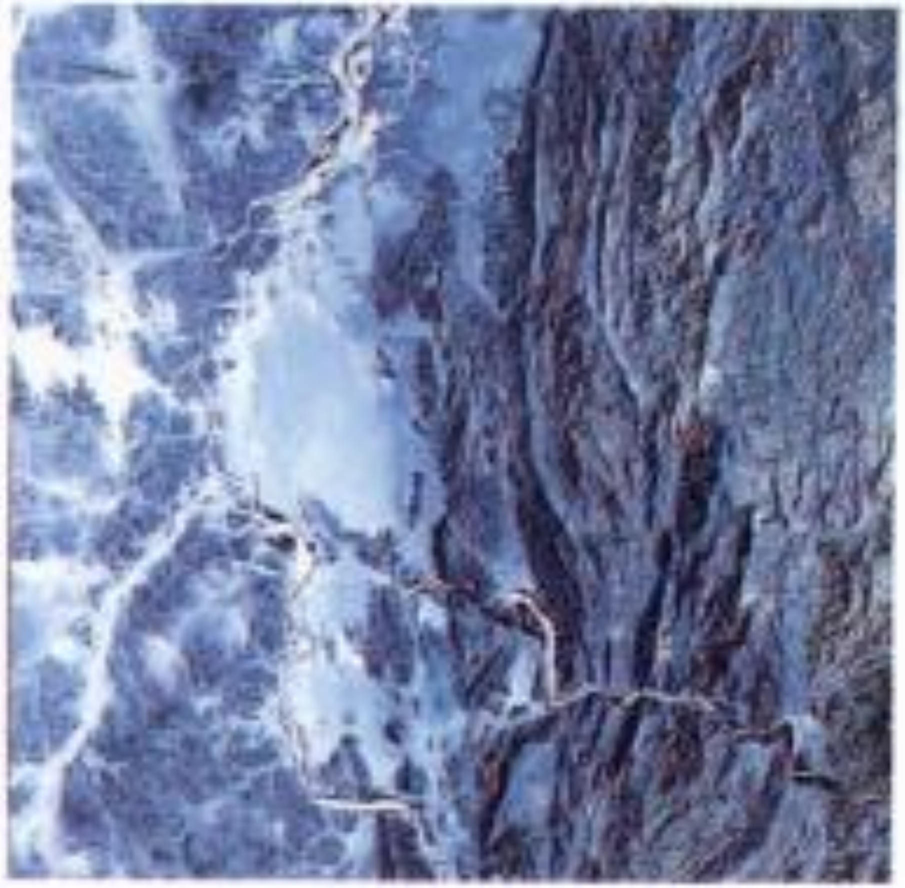
(b)



TM 432 RGB

Figure 5.10 These linearly stretched false-colour Landsat TM images of part of the Sudan–Eritrea border are of the area shown in Figures 5.4 to 5.9. They reveal more details than the band 3 images in both light and dark terrains, but each band combination contains different information. The natural colour image (bands 3, 2 and 1 as RGB) (a) is least informative. The standard false-colour composite (bands 4, 3 and 2 as RGB) (b) shows vegetation in shades of red, but little more than (a). Combining bands 5, 3 and 1 in RGB (c) reveals better detail of the distribution of different rock types, while suppressing vegetation as dark tones. The importance of a correct assignment of bands to colour components is shown by (d), which has bands 3, 1 and 5 in RGB. Exactly the same information as in (c) is shown, but the choice of colours prevents the eye from appreciating the full range of variability. The geology is of a major boundary between a high-grade metamorphic terrain with granite intrusions and basaltic dykes to the left, and a very complex, younger terrain of peridotites, metabasalts and metasediments to the right. The boundary is marked by deep alluvium along a major river controlled by a huge shear zone. Each image is 30 km across.

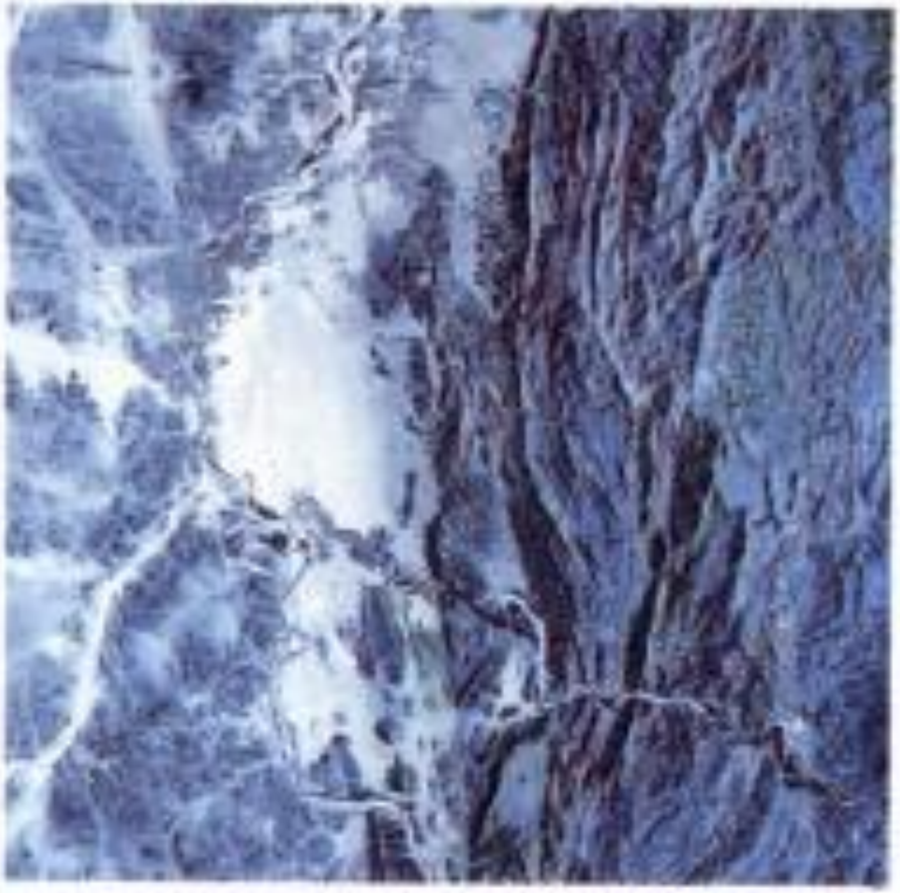
(c)



TM 531 RGB

Figure 5.10 These linearly stretched false-colour Landsat TM images of part of the Sudan–Eritrea border are of the area shown in Figures 5.4 to 5.9. They reveal more details than the band 3 images in both light and dark terrains, but each band combination contains different information. The natural colour image (bands 3, 2 and 1 as RGB) (a) is least informative. The standard false-colour composite (bands 4, 3 and 2 as RGB) (b) shows vegetation in shades of red, but little more than (a). Combining bands 5, 3 and 1 in RGB (c) reveals better detail of the distribution of different rock types, while suppressing vegetation as dark tones. The importance of a correct assignment of bands to colour components is shown by (d), which has bands 3, 1 and 5 in RGB. Exactly the same information as in (c) is shown, but the choice of colours prevents the eye from appreciating the full range of variability. The geology is of a major boundary between a high-grade metamorphic terrain with granite intrusions and basaltic dykes to the left, and a very complex, younger terrain of peridotites, metabasalts and metasediments to the right. The boundary is marked by deep alluvium along a major river controlled by a huge shear zone. Each image is 30 km across.

(d)

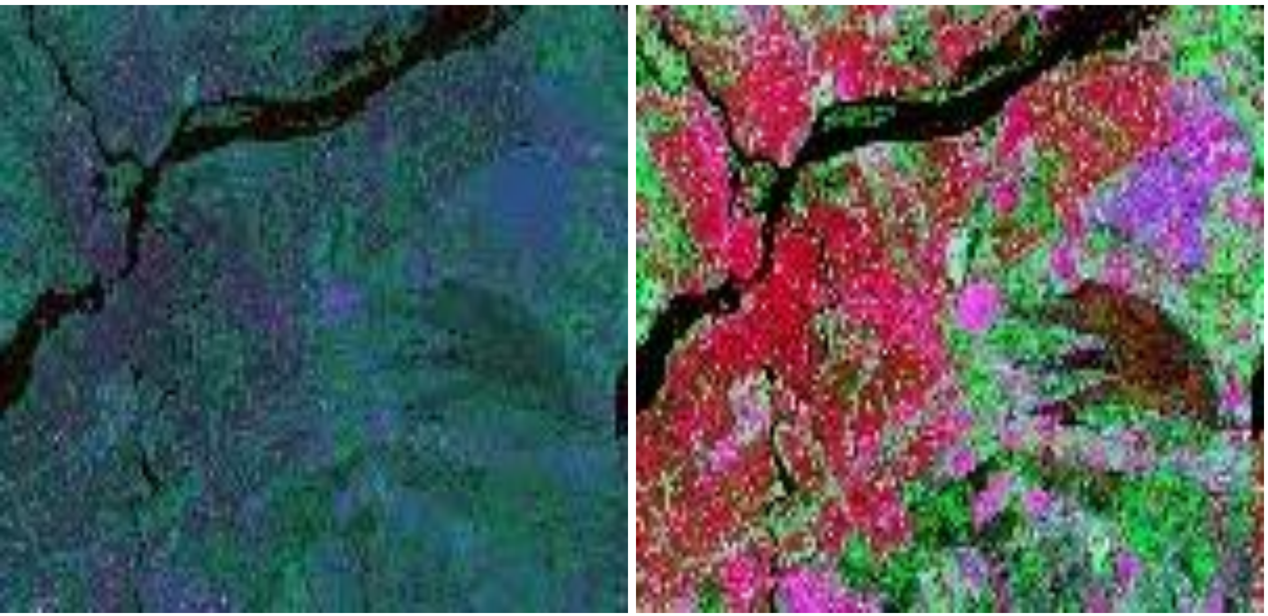


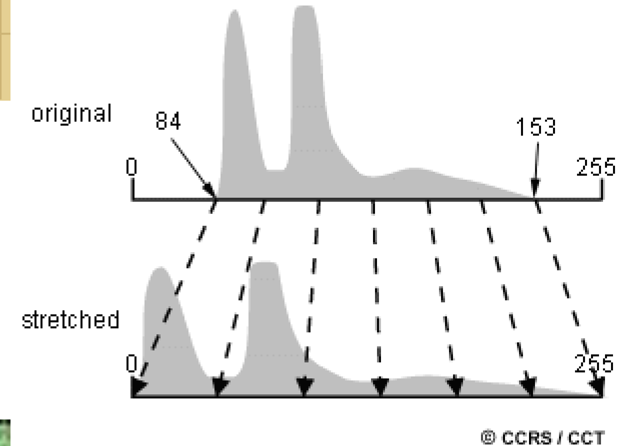
TM 315 RGB

Figure 5.10 These linearly stretched false-colour Landsat TM images of part of the Sudan–Eritrea border are of the area shown in Figures 5.4 to 5.9. They reveal more details than the band 3 images in both light and dark terrains, but each band combination contains different information. The natural colour image (bands 3, 2 and 1 as RGB) (a) is least informative. The standard false-colour composite (bands 4, 3 and 2 as RGB) (b) shows vegetation in shades of red, but little more than (a). Combining bands 5, 3 and 1 in RGB (c) reveals better detail of the distribution of different rock types, while suppressing vegetation as dark tones. The importance of a correct assignment of bands to colour components is shown by (d), which has bands 3, 1 and 5 in RGB. Exactly the same information as in (c) is shown, but the choice of colours prevents the eye from appreciating the full range of variability. The geology is of a major boundary between a high-grade metamorphic terrain with granite intrusions and basaltic dykes to the left, and a very complex, younger terrain of peridotites, metabasalts and metasediments to the right. The boundary is marked by deep alluvium along a major river controlled by a huge shear zone. Each image is 30 km across.

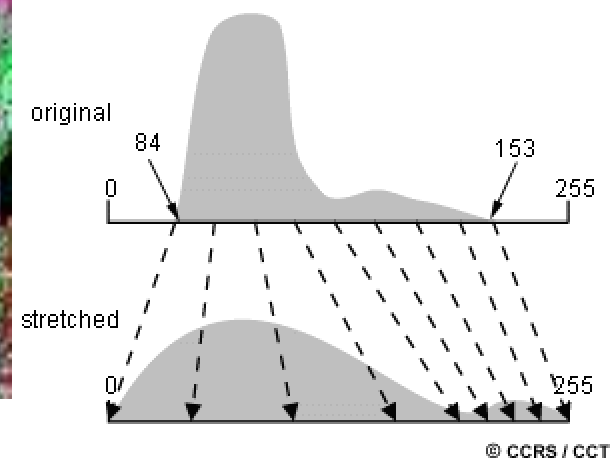
úpravy kontrastu

roztažení histogramu





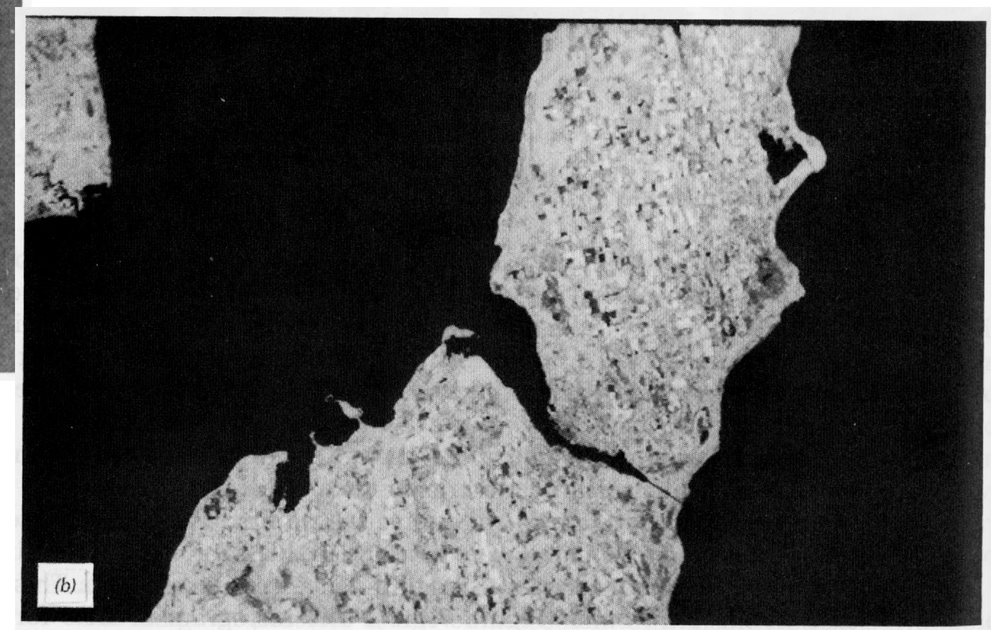
lineární



vyrovnání histogramu

histogram

TM1



TM4

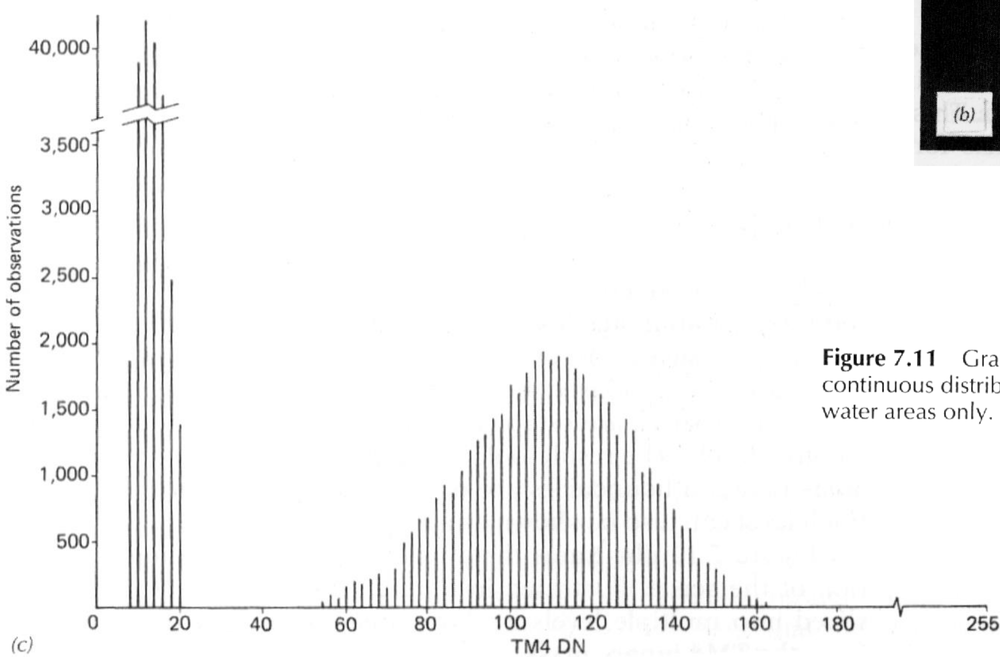
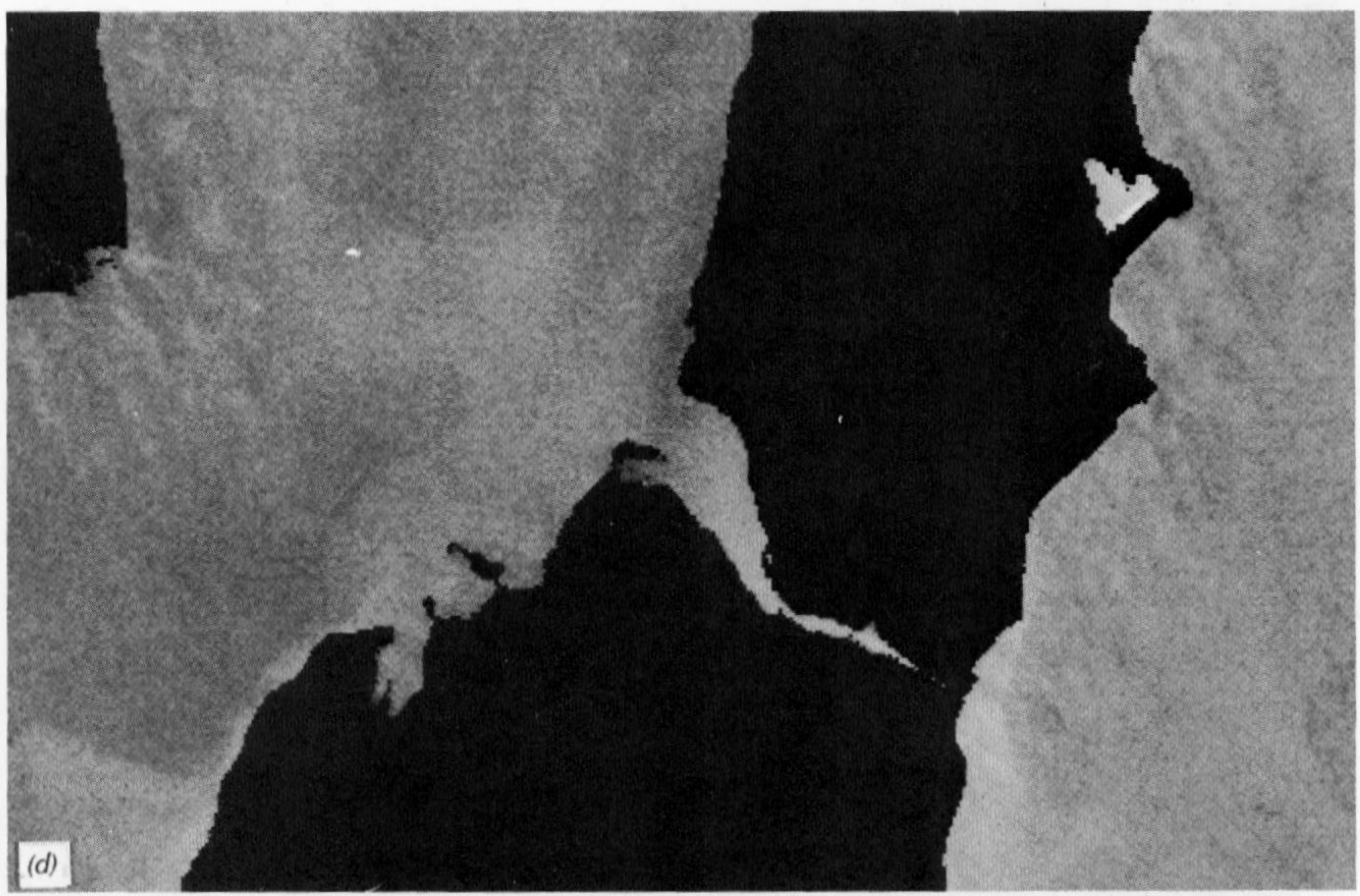
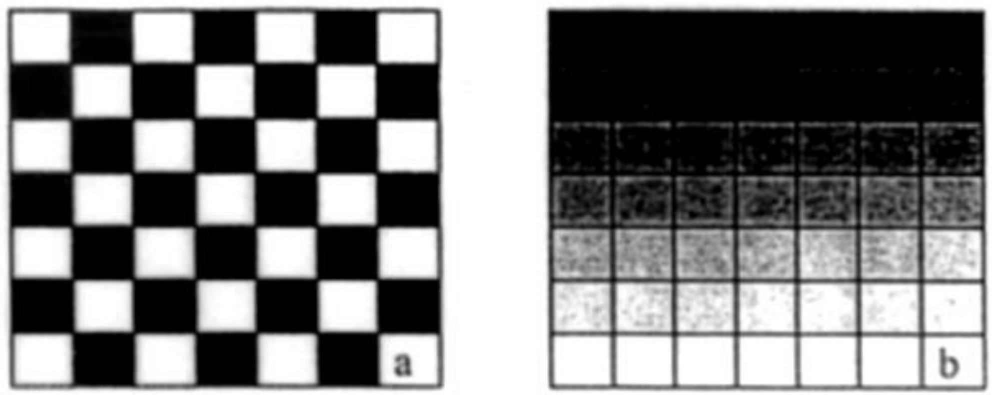


Figure 7.11 Gray-level thresholding for binary image segmentation: (*a*) original TM1 image containing continuous distribution of gray tones; (*b*) TM4 image; (*c*) TM4 histogram; (*d*) TM1 brightness variation in water areas only.



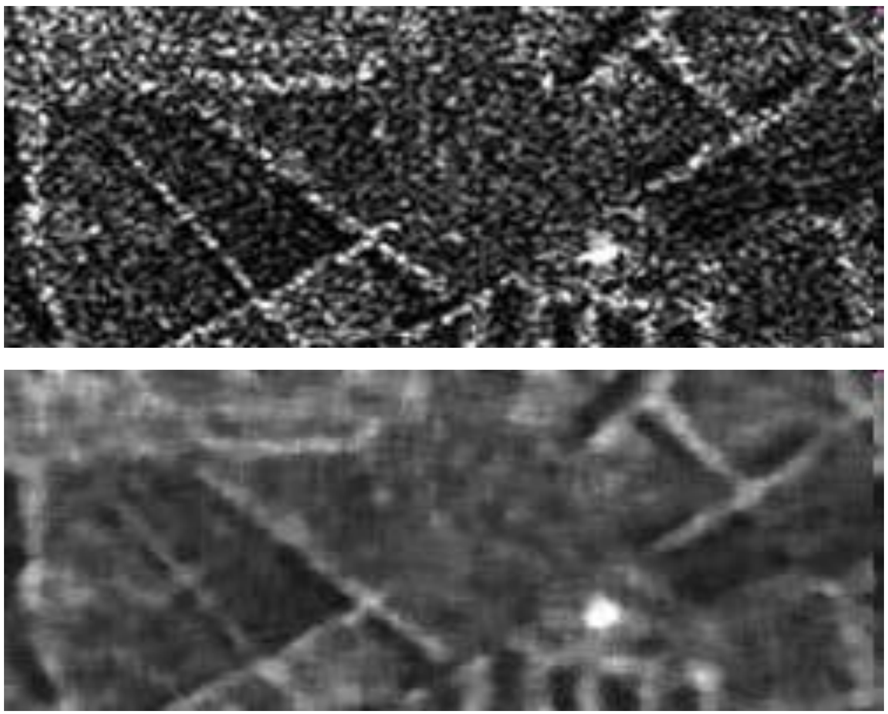
TM1, pouze voda

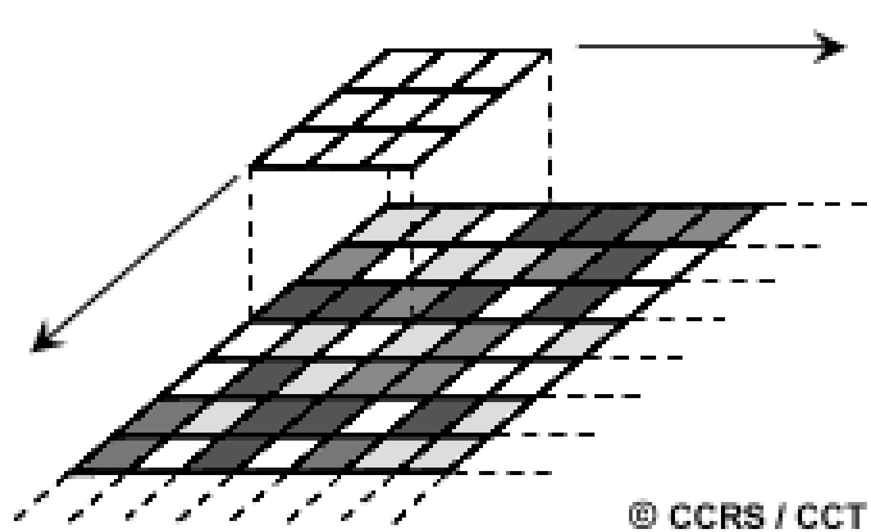
prostorové filtry - kernely



Obr. 8.8 Příklad vysokofrekvenční (a) a nízkofrekvenční (b) informace v obraze

low-pass filtr





© CCRS / CCT

What is a low pass filter?

If you apply Smooth to continuous data, the low pass filter lessens the spatial frequency of the data. A low pass filter moves a 3 x 3 matrix throughout the image. The output pixel values are obtained using a convolution kernel. The effect of the kernel is that pixel values are averaged.

Your original data file values may be like the following:

2	2	2
2	**3**	2
2	2	2

Where the target pixel is in the center, **3.**

A low pass convolution kernel is applied over those values as follows:

1	1	1
1	1	1
1	1	1

Using the convolution kernel, the center pixel of the data matrix, 3, is multiplied by the kernel value of the same position, 1. Then the products of all the multiplications are added and the total is divided by the sum of the values in the convolution kernel as follows:

((1 x 2) + (1 x 2) + (1 x 2) +

(1 x 2) + (1 x 3) + (1 x 2) +

(1 x 2) + (1 x 2) + (1 x 2)) / (1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1)

= (19/9) = (2) = 2

In this example, the target pixel's output value is **2.**

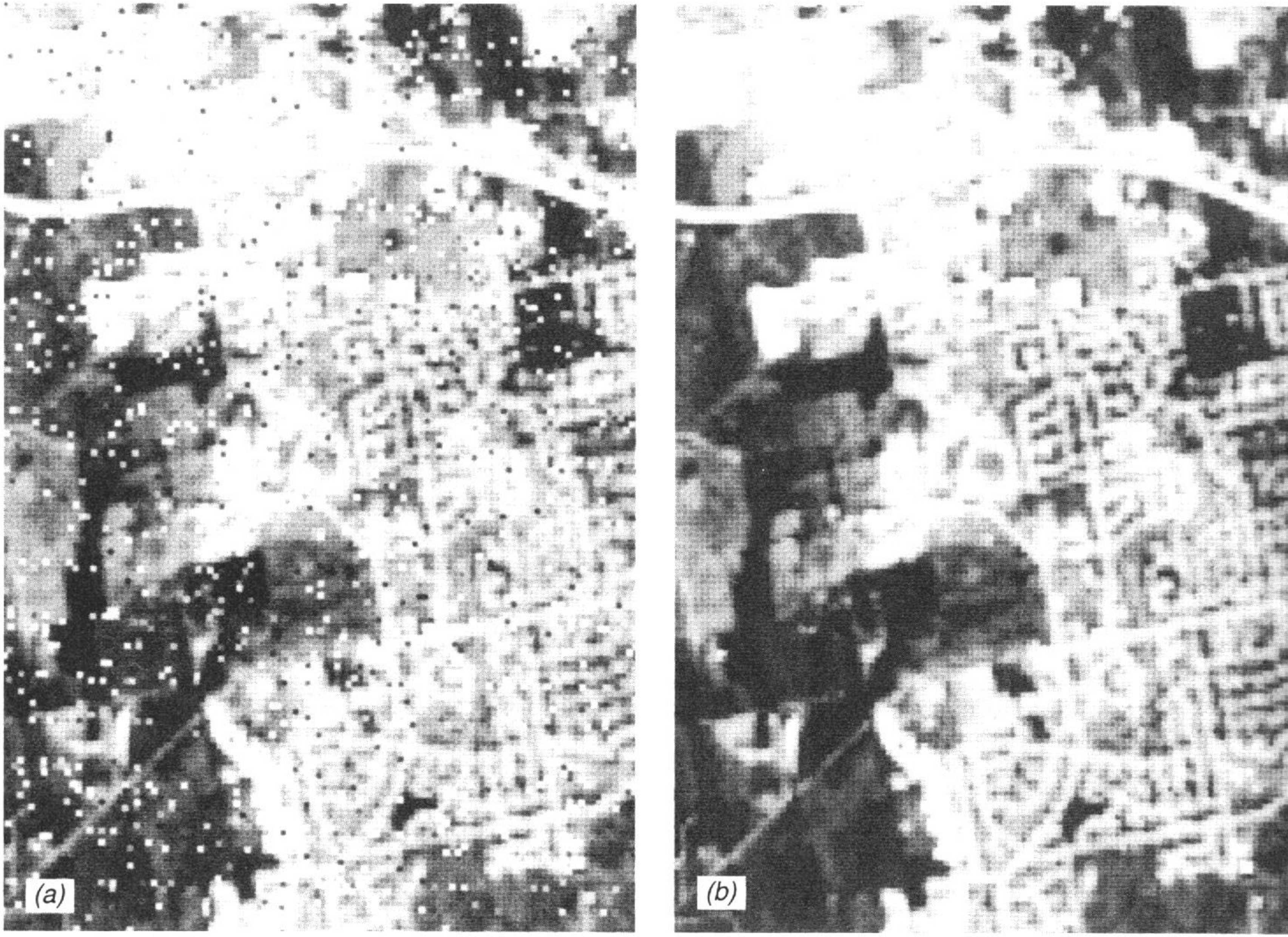
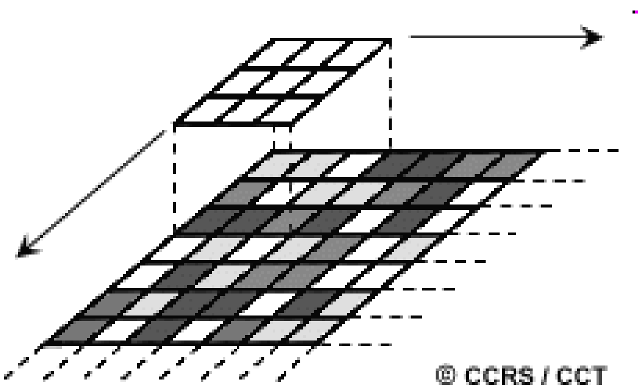
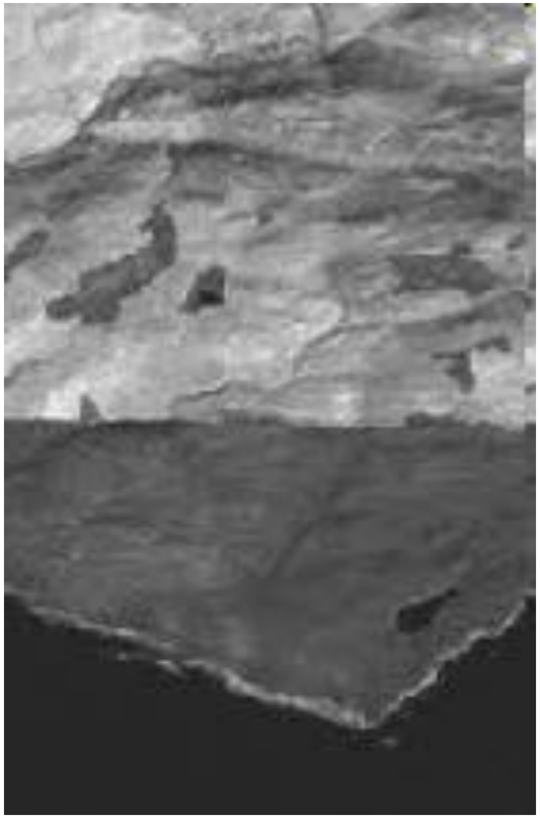
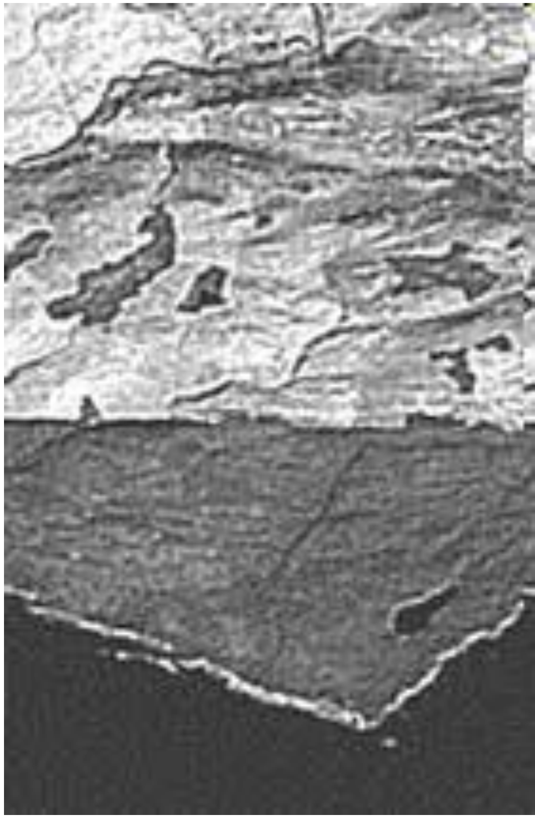


Figure 7.10 Result of applying noise reduction algorithm: (*a*) original image data with noise-induced "salt-and-pepper" appearance; (*b*) image resulting from application of algorithm shown in Figure 7.9.

high-pass/sharpen - filtr zostření







This is how the Sharpen convolution kernel works

The size of the convolution kernel takes into account the number of pixels surrounding the target pixel. During the Sharpen function, the center pixel in the 5 x 5 matrix is given the largest weight or most importance, and the pixels that surround it are given a negative weight.

Your original data file values may be like the following:

4	1	1	1	1
4	2	2	2	1
3	2	**3**	2	1
2	2	2	2	1
2	1	1	1	1

Where the target pixel is in the center, **3.**

The edge-enhancing 5 x 5 summary convolution kernel below is applied to those values as follows:

-1	-1	-1	-1	-1
-1	-2	-2	-2	-1
-1	-2	70	-2	-1
-1	-2	-2	-2	-1
-1	-1	-1	-1	-1

By using the convolution kernel, the center pixel of the data matrix, 3, is multiplied by the kernel value of the same position, 70. Then the products of all the multiplications are added and the total is divided by the sum of the values in the convolution kernel as follows:

((-1 x 4) + (-1 x 1) + (-1 x 1) + (-1 x 1) + (-1 x 1) +

(-1 x 4) + (-2 x 2) + (-2 x 2) + (-2 x 2) + (-1 x 1) +

(-1 x 3) + (-2 x 2) + (70 x 3) + (-2 x 2) + (-1 x 1) +

(-1 x 2) + (-2 x 2) + (-2 x 2) + (-2 x 2) + (-1 x 1) +

(-1 x 2) + (-1 x 1) + (-1 x 1) + (-1 x 1) + (-1 x 1)) / (70 + -32)

=(152/38) = (4) = 4

In this example, the target pixel's output value is **4.**

transformace obrazu

- algebraické operace se spektrálními pásmy
- RGB-HSI transformace
- dekorelační roztažení histogramu
- analýza hlavní komponenty
- klasifikace

algebraické operace se spektrálními pásmy

podíl

RATIO (λ)	MATERIAL A	MATERIAL B	
$\frac{0.4}{0.6}$	$\frac{15}{25} = 0.6$	$\frac{20}{55} = 0.36$	R
$\frac{0.7}{0.9}$	$\frac{26}{35} = 0.74$	$\frac{71}{53} = 1.34$	G
$\frac{1.2}{1.6}$	$\frac{34}{36} = 0.94$	$\frac{92}{113} = 0.81$	B

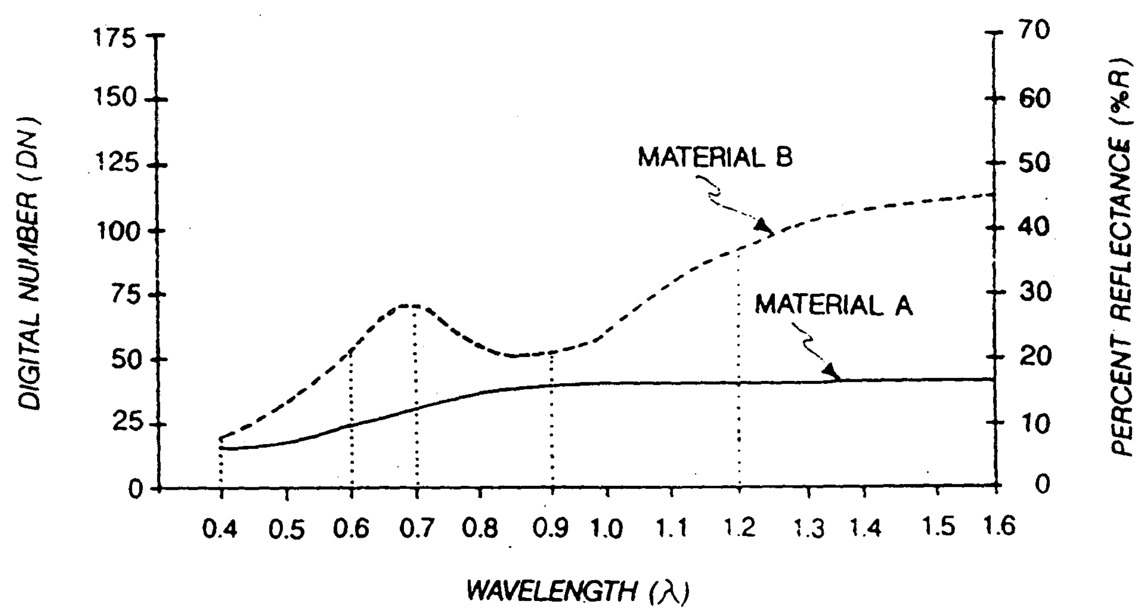


Figure 6.1 Hypothetical reflectance curves showing how ratios enhance minor reflectance variations. From Prost [6].

TM 5/4 3/1 5/7 jako RGB HSI transformace

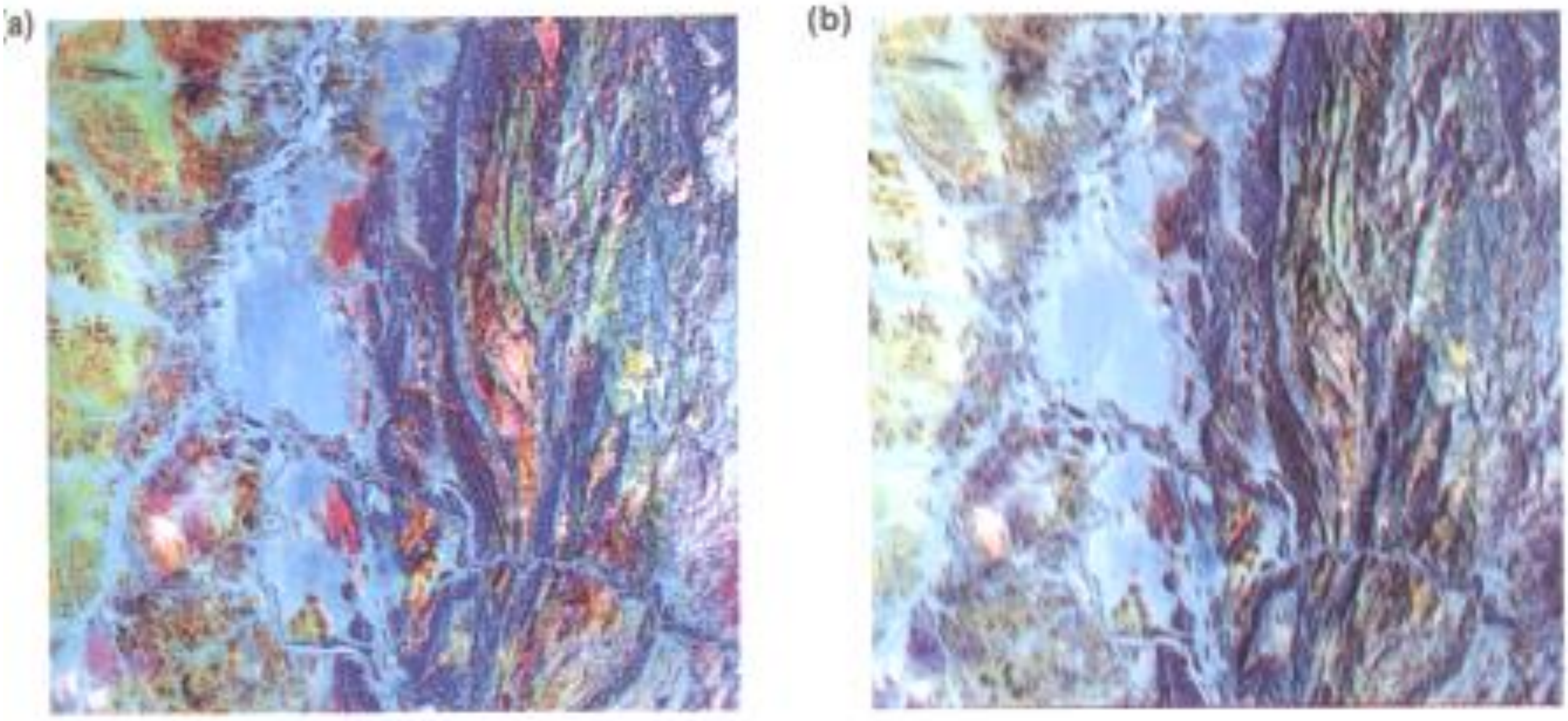


Figure 5.30 (a) False-colour ratio image of the area of Figure 5.31, using TM 5/4 as red, 3/1 as green and 5/7 as blue. Though producing an excellent discrimination of rock types, the image lacks some topographic detail and is noisy. By using the ISH transform and substituting a contrast-stretched TM band for the ratio intensity, (b) both defects can be avoided without changing the colour rendition of different rocks, which is dependent on spectral features related to iron minerals, albedo and hydroxy-bearing minerals. Both should be compared with *Figures 5.14* and *5.26*.

algebraické operace se spektrálními pásmy

J. G. Liu © Imperial College

TM vegetation index

$$Y = \frac{TM4 - \mathrm{Min}(TM4)}{TM3 - \mathrm{Min}(TM3)} \quad \textbf{(4-11)}$$

$$Y = \frac{TM4 - TM3}{TM4 + TM3} \quad \textbf{(4-12)}$$

TM clay mineral ratio index

$$Y = \frac{TM5 - \mathrm{Min}(TM5)}{TM7 - \mathrm{Min}(TM7)} \quad \textbf{(4-13)}$$

ATM clay mineral difference index

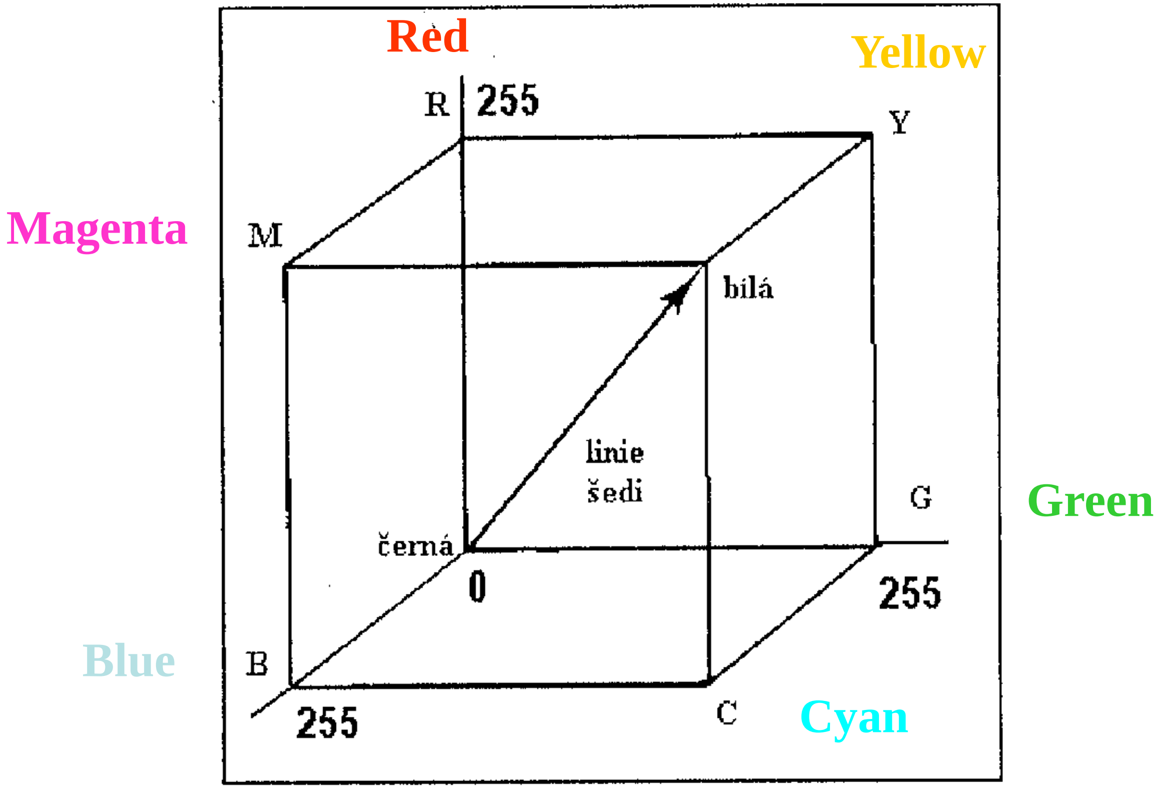
$$Y = (ATM9 + ATM4) - (ATM10 + ATM2) \quad \textbf{(4-14)}$$

TM iron oxide ratio index

$$Y = \frac{TM3 - \mathrm{Min}(TM3)}{TM2 - \mathrm{Min}(TM2)} \quad \textbf{(4-15)}$$

ATM gypsum enhancement colour composite

$$\begin{array}{ll} Red & ATM9 - ATM10 \\ Green & ATM8 - ATM10 \\ Blue & ATM2 - ATM10 \end{array} \quad \textbf{(4-16)}$$



Obr. 8.17 Princip RGB barevného systému, RGB - základní barvy (červená, zelená a modrá), CMY - barvy komplementární (Cyan - azurová, Magenta - purpurová, Yellow - žlutá)

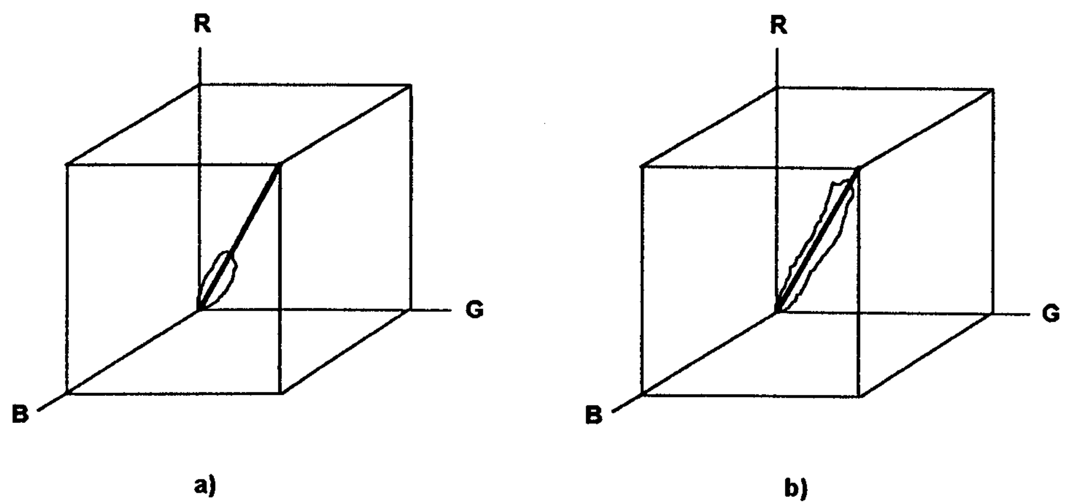
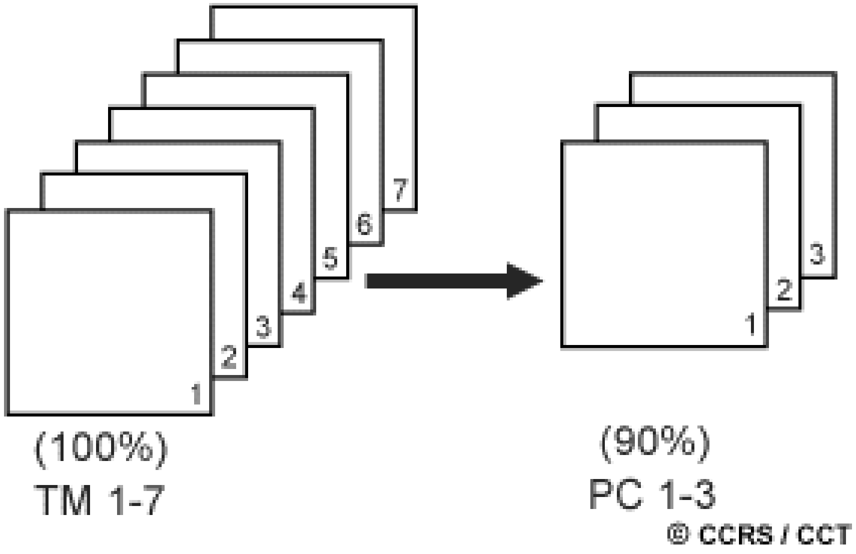


Figure 6-2 (a) Distribution of pixels in RGB cube for typical correlated bands. (b) Effect of stretching each band. The data is not stretched to fill the RGB cube by this operation.

- analýza hlavní komponenty



analýza hlavní komponenty, dekorelační roztažení histogramu

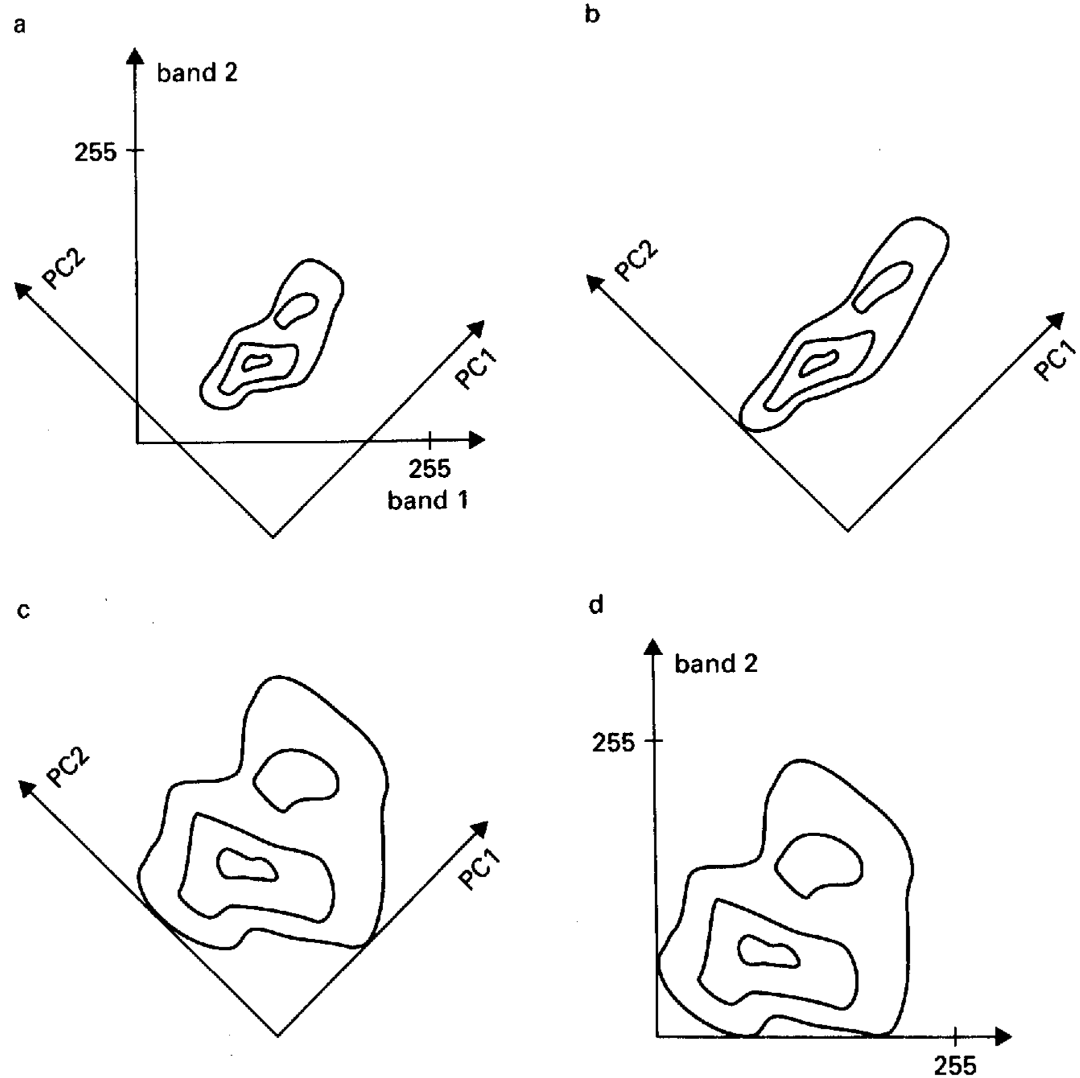


Figure 5.27 (a) A bivariate plot of two bands with PC axes superimposed. In (b) the first PC has been stretched after rotation of the axes to PC space, the second PC having been stretched in (c). This shows how it is possible to produce a decorrelation of the data in PC space. (d) The decorrelated data have been rotated back to original band space, the original correlation having been drastically reduced, although each pixel is still in its original position relative to all the others. Compare with Figure 5.12.

PC1, PC2, PC3 jako RGB

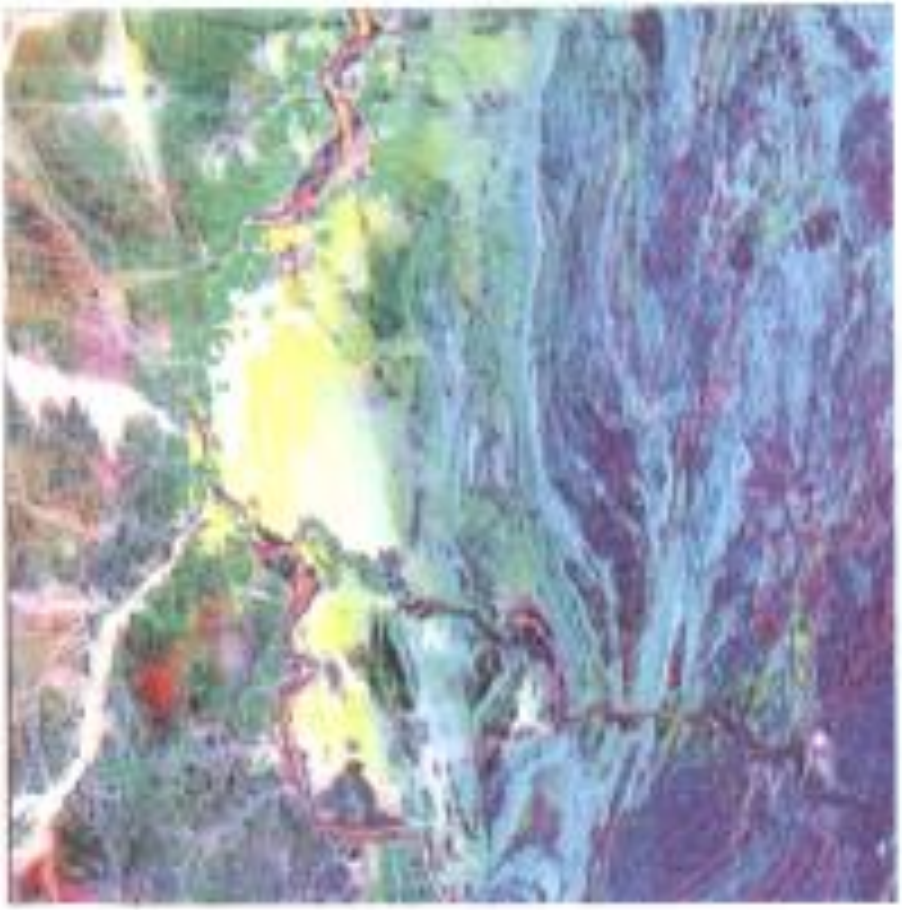


Figure 5.26 This image combines the first-, second- and third-order principal components from the area of *Figures 5.10* and 5.11 in red, green and blue. The result is a vivid colour representation of surface variations in which much geological detail is visible, particularly different kinds of rock. However, the colours are not easily related to the rocks' spectral properties, and the compression of most of the variance into the first PC means that the other PCs are noisy and noise interferes with interpretation in the false-colour image.

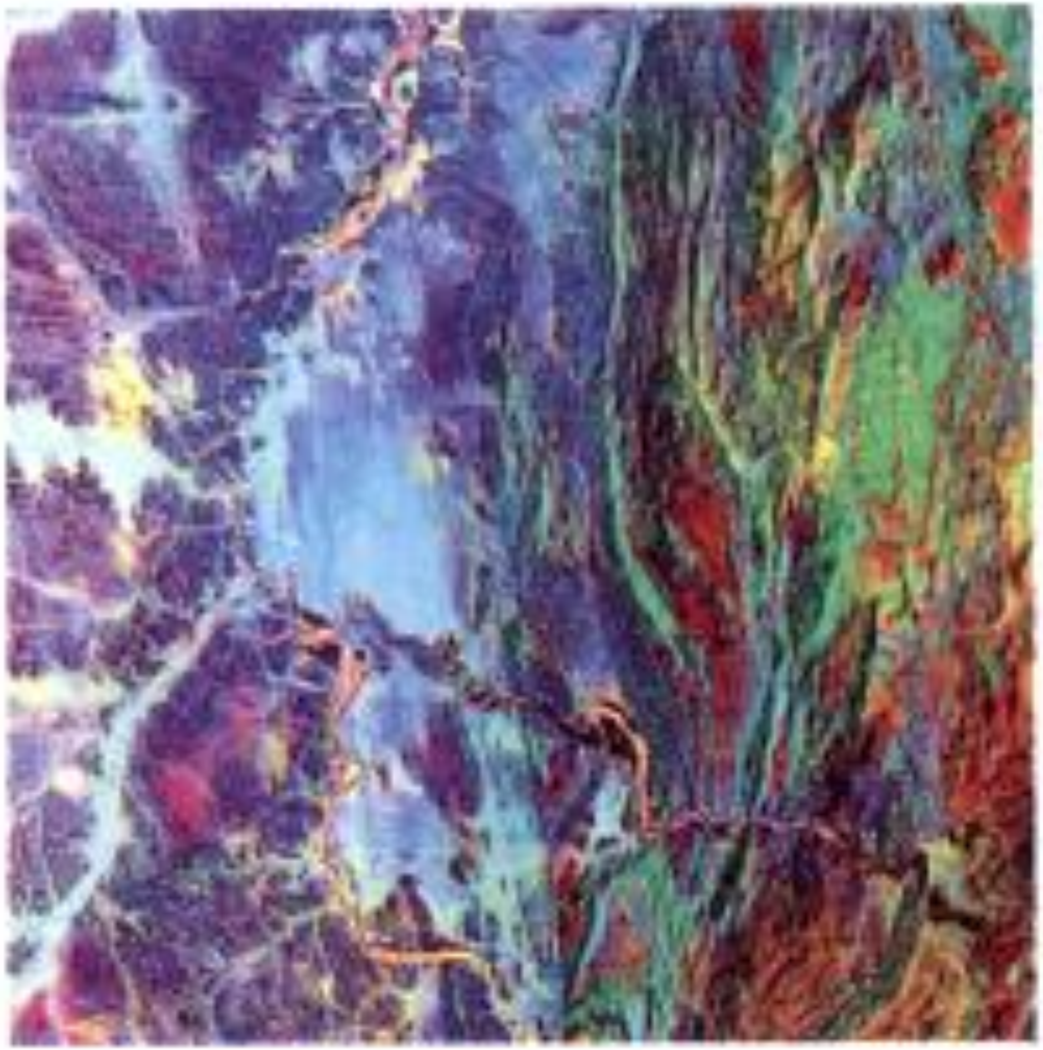
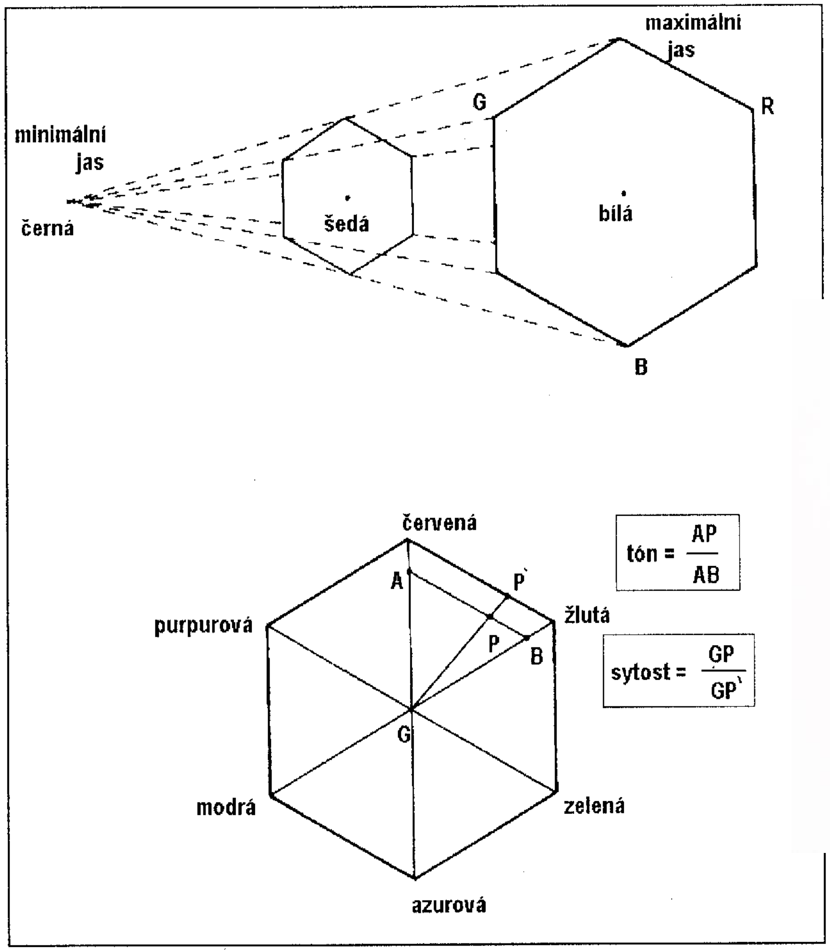
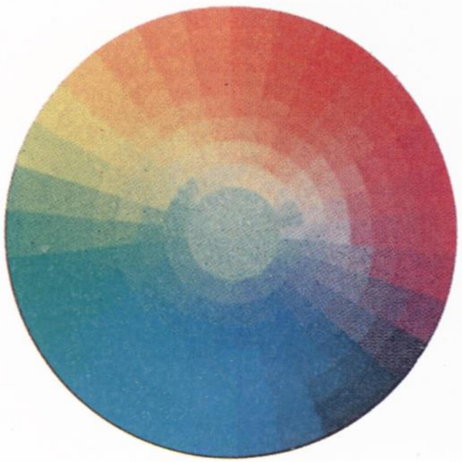


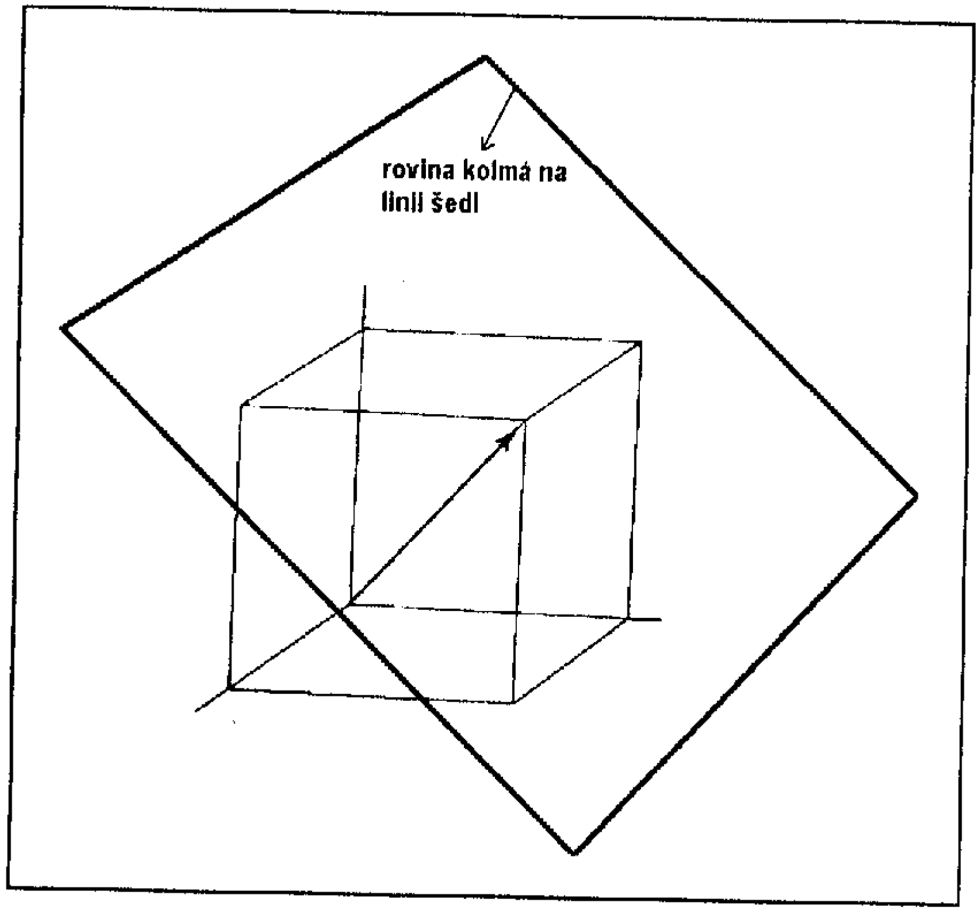
Figure 5.28 Decorrelation- or D-stretched image of Landsat TM bands 5, 3 and 1 in RGB for the same area as *Figure 5.10c*. The first PC was stretched and edge enhanced, and higher order PCs filtered to remove noise before rotation back to original band space. It shows little difference compared with *Figure 5.14*, but the D-stretch technique offers more opportunities for cosmetic improvement than the ISH transform.



r. 8.19 Definování jednotlivých složek barevného systému IHS (jasu, tónu a sytosti).
Podle LILLESANDA a KIEFERA (1994)

Figure 5.13 (b) This cross section through the conical representation of HSI colour space shows how pure spectral hues on the perimeter grade through pastel shades to grey at the axis of the cone. Courtesy of LogE Ltd.





Obr. 8.18 Možný způsob transformace RGB a IHS barevného systému

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P – Intensity

α – Hue

φ - Saturation

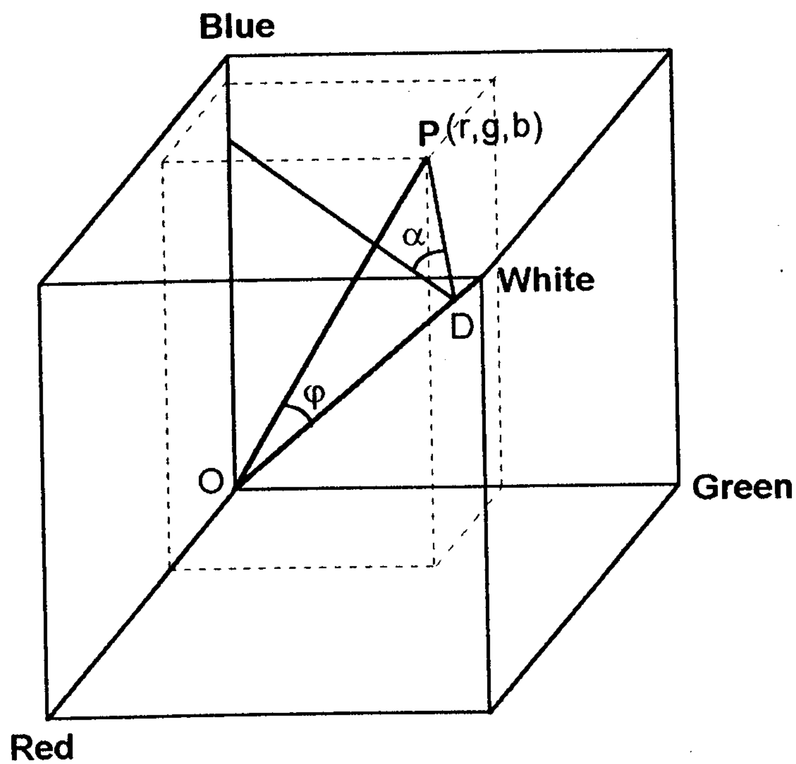


Figure 6-1 The colour cube model for RGB-HSI transformation.

As shown in Figure 6-1, any a colour in a three band colour composite is a vector $\mathbf{P}_i = (r_i, g_i, b_i)$ within a colour cube with edge length of 255 (for 24 bits RGB colour display). The major diagonal line connecting the origin and the furthest vertex is called grey line because the pixels lying on this line have equal components in red, green and blue *(r=g=b)*. The intensity of a colour vector **P** is defined as the length of its projection on the grey line, *OD*, and the hue the azimuth angle around the grey line, α, and the saturation the angle between the colour vector **P** and the grey line, φ. Saturation can be simply calculated as the ratio of the difference of the maximum and minimum of *r*, *g* and *b* against the maximum of *r*, *g* and *b* (Smith 1978). Let the hue angle of pure blue colour be zero, we then have following RGB-HSI transformation:

$$I(r,g,b) = \frac{1}{\sqrt{3}}(r+g+b) \tag{6-1}$$

$$H(r,g,b) = \cos^{-1}\frac{2b-g-r}{2V} \tag{6-2}$$

$$\text{where} \quad V = \sqrt{(r^2+g^2+b^2)-(rg+rb+gb)}$$

$$S(r,g,b) = \frac{Max(r,g,b)-Min(r,g,b)}{Max(r,g,b)} \tag{6-3}$$

RGB-HSI transformation can also be derived by vector analysis and matrix operation based on the same colour cube model (Niblack, 1986) as following:

$$\begin{pmatrix} I \\ v_1 \\ v_2 \end{pmatrix} = \begin{pmatrix} 1/3 & 1/3 & 1/3 \\ -1/\sqrt{6} & -1/\sqrt{6} & 2/\sqrt{6} \\ 1/\sqrt{6} & -2/\sqrt{6} & 0 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix} \quad (6\text{-}4)$$

$$H = \tan^{-1}(v_2 / v_1) \quad (6\text{-}5)$$

$$S = \sqrt{v_1^2 + v_2^2} \quad (6\text{-}6)$$

HSI-RGB transformation:

$$\begin{pmatrix} R \\ G \\ B \end{pmatrix} = \begin{pmatrix} 1 & -0.204 & 0.612 \\ 1 & -0.204 & -0.612 \\ 1 & 0.408 & 0 \end{pmatrix} \begin{pmatrix} I \\ v_1 \\ v_2 \end{pmatrix} \quad (6\text{-}7)$$

$$\begin{aligned} v_1 &= S \cos 2\pi H \\ v_2 &= S \sin 2\pi H \end{aligned} \quad (6\text{-}8)$$

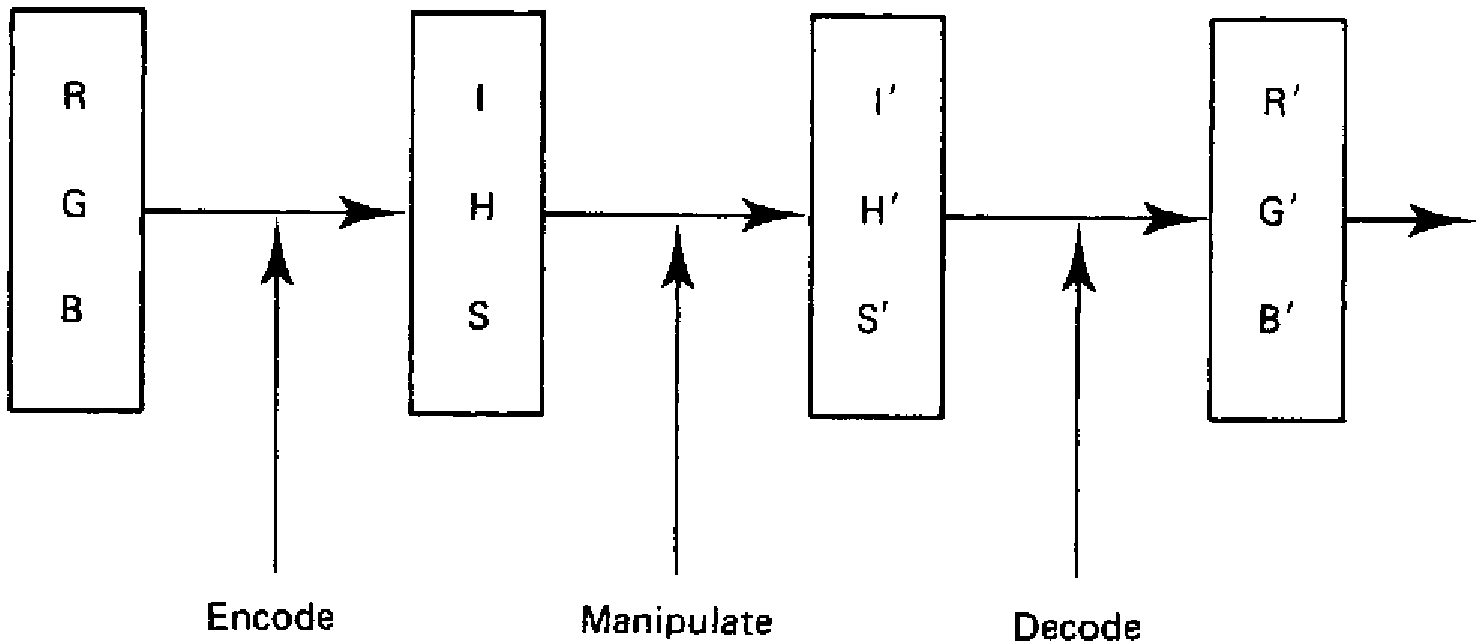


Figure 7.36 IHS/RGB encoding and decoding for interactive image manipulation. (Adapted from Schowengerdt, 1997.)

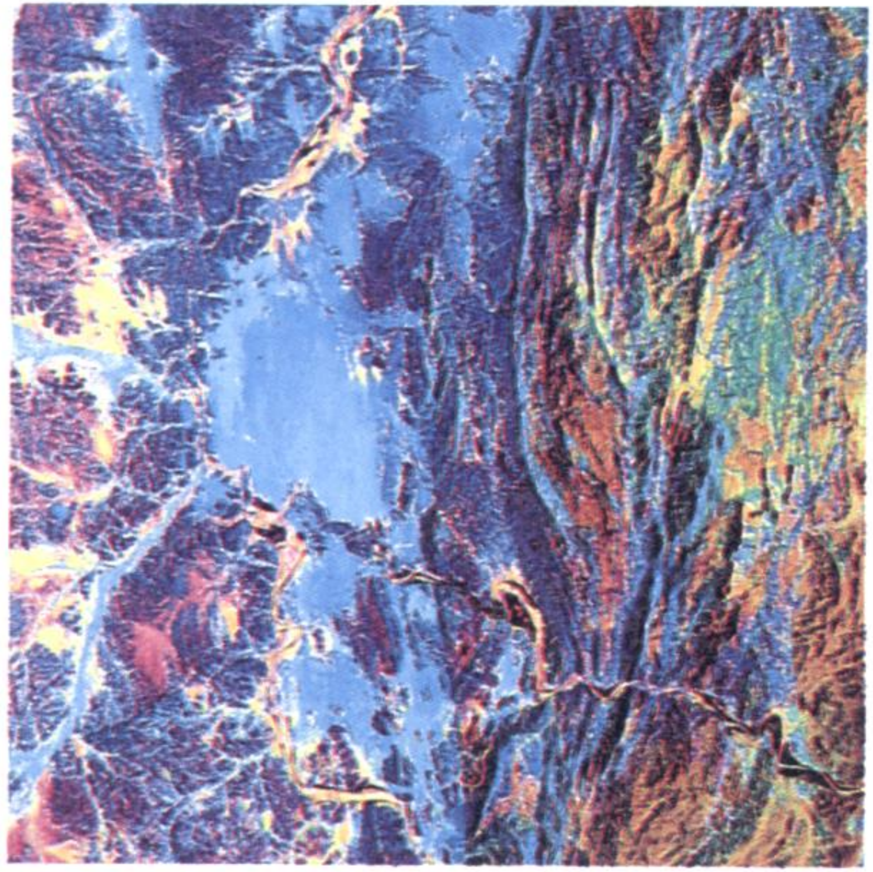
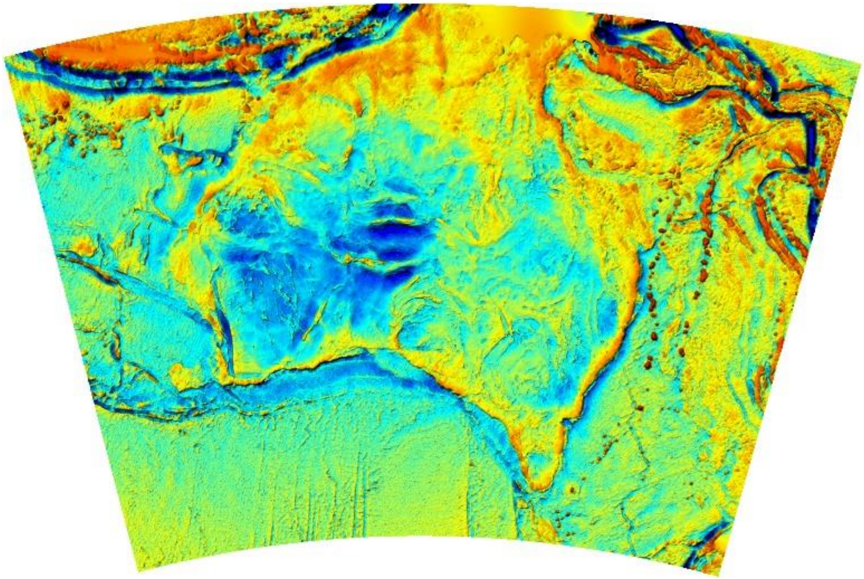


Figure 5.14 The Landsat TM band 5, 3 and 1 data in *Figure 5.10c* have been transformed to ISH coordinates, with the intensity and saturation files stretched and the hue unchanged. The results have been transformed back to RGB space to produce a vivid range of colours. Comparison of the two images reveals that the basic colour differences in the image have not been changed, so that colour can still be related easily to spectral properties.

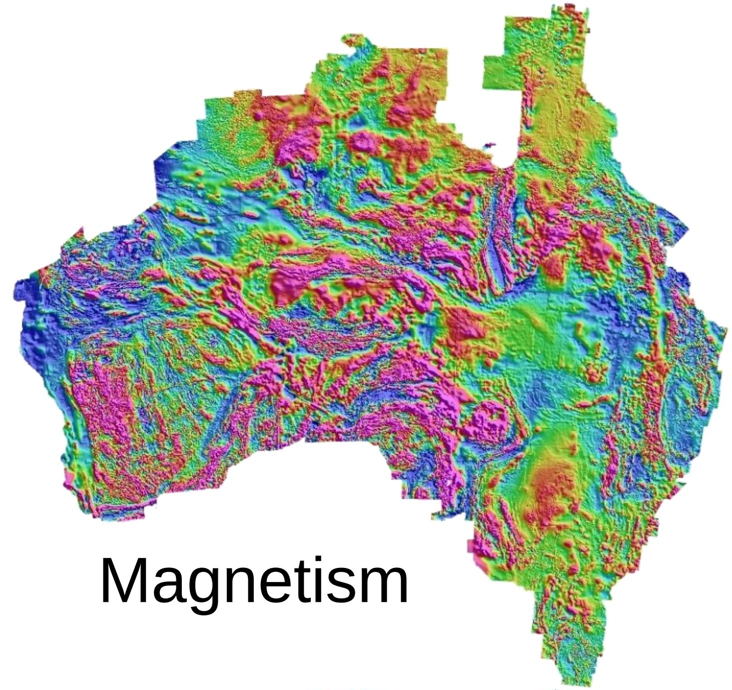
GIS – integrace a analýza různých typů dat

- geologické a strukturní mapy
- geofyzikální data
- geochemická data
- snímky

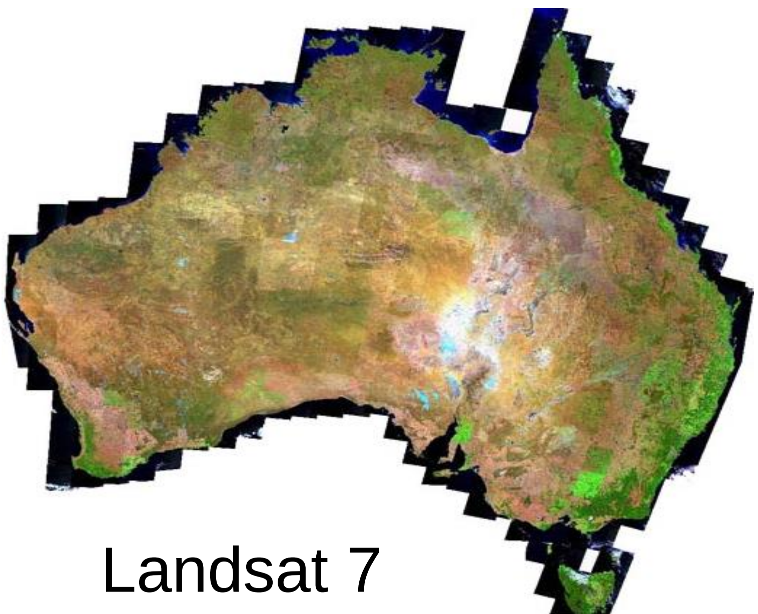
Other Data



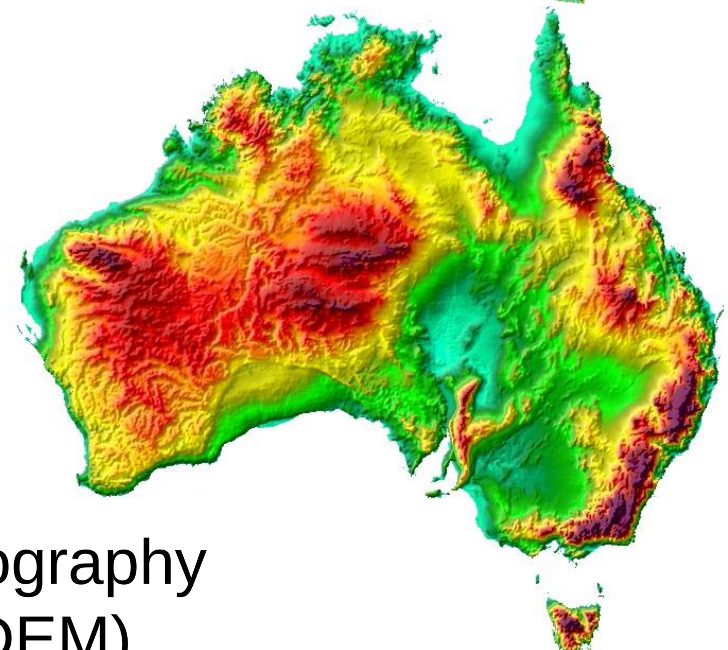
Gravity



Magnetism



Landsat 7
Mosaic



Topography
(DEM)

The depth of penetration of sensors