### Table 3. Classification and properties of brown coals and the distinction between 'Braunkohle' and 'Steinkohle' (according to German usage)¹

<table>
<thead>
<tr>
<th>Rank of coal</th>
<th>Megascopic</th>
<th>Microscopic</th>
<th>Chemical-Physical</th>
<th>Behaviour on boiling with KOH</th>
<th>Behaviour with dilute HNO₃</th>
</tr>
</thead>
</table>
| Weichbraunkohle (soft brown coal) | brown, dull, partly earthy | large pore volume, gelification rare, open cell lumens (textinite) | 75–35% H₂O  
< 4000 kcal/kg<sup>2</sup>  
usually > 60 – < 70% C<sup>3</sup> | brown, seldom black | brown solution |
| Mattbraunkohle (dull brown coal) | dark brown to black, dull to low brightness | less pore volume, stronger gelification, open cell lumens (textinite) rare | 35–25% H₂O  
4000–5500 kcal/kg<sup>2</sup>  
usually < 71 – ca. 71% C<sup>3</sup>  
ca. 53–49% VM<sup>3</sup> | brown, seldom black | red solution |
| Braunkohle (hard brown coal)  | black, bright            | gelification (vitritinitization) completed, micrinite not yet formed | usually > 8–10% H₂O  
5500–7000 kcal/kg<sup>2</sup>  
ca. 71–77% C<sup>3</sup>  
ca. 49–42% VM<sup>3</sup> | brown, seldom black | black, no colour |
| Steinkohle (bituminous coal) | black, bright            | like Glanzbraunkohle, micrinite formed           | usually < 8–10% H₂O  
usually > 7000 kcal/kg<sup>2</sup>  
usually > 77% C<sup>3</sup>  
usually < 42% VM<sup>3</sup> | black, seldom brown | black, no colour |

¹ for correlation with the ASTM classification see Table 4  
² moist, ash-free  
³ dry, ash-free; VM = volatile matter
Fig. 16. Coalification tracks of different macerals based on H/C: O/C atomic ratios (after van Krevelen, 1961).
Fig. 17. Increase of degree of coalification with depth based on vitrite analyses and vitrinite reflectivities from deep boreholes and shafts, mainly in the Ruhr district (after M. & R. Teichmüller, 1967).
Fig. 18. Relationship between vitrinite reflectance and different chemical-rank parameters (after M. Teichmüller, 1971).
Fig. 19. Physical, chemical and molecular changes of vitrinite during the coalification of bituminous coals and anthracites (based on different authors; see M. & R. Tschitschulgen,
1954 a, 1968 a).

- high volatile bituminous coal (~35% vol. m.)
- medium volatile bituminous coal (~22% vol. m.)
- anthracite (~5% vol. m.)

1. Aromacity
2. Ring condensation
3. Dimension of aromatic clusters (crystallites —-)
4. Free radicals
5. Solubility in ethylenediamine

First row: molecular structure
- \( \text{o} = \) hydrogen bonding
- \( \text{—} = \) molecular bonding

Second row: orientation of molecules perpendicular to the bedding plane
- lenses = aromatic clusters
- lines = non-aromatic elements

Third row: development of chemical properties in relation to carbon content (daf)

Fourth row: development of physical properties in relation to carbon content (daf)
KÖMÜRLEŞMENİN NEDENLERİ
Fig. 21. Course of isorank lines (e.g. isovols, isoreflectances) in cross-sections of a folded area after a) preorogenic; b) synorogenic and c) postorogenic coalification (after M. & R. Teichmüller, 1966 a).