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Modelling of Rayleigh-type seam waves in disturbed coal seams and around a coal mine roadway

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For a site investigation of the rock structure beyond the heading face during the drivage of new tunnels, several methods have been developed in the past few years in civil engineering. Up to now no system based on seismic methods exists that provides such information in coal mining. Such a technique can help to reduce the financial risk of shut downs of the mining operation and the hazards for the miners. Since in coal mining, roadways are usually driven parallel to the seam, dispersive seam waves can be generated by locating for example explosive sources within the seam. Due to their cylindrical geometrical spreading seam waves are suitable for the investigation of the structure and layering of coal seams.

Wave propagation in coal seams is numerically modelled in order to identify approaches towards the reconnaissance beyond the heading face of an advancing coal mine roadway. Complete synthetic wavefields including P-SV body waves and Rayleigh-type seam waves are calculated using a Green's function approach for simple, laterally homogeneous models and a parallel elastic 2-D/3-D finite-difference modelling code for more realistic geometries.

For a simple three-layer model the wavefield within the seam is dominated by a fundamental Rayleigh seam mode. If the seam contains an interleaved dirt band with higher velocities and density, higher modes dominate the wave propagation. Wave propagation in laterally inhomogeneous coal seam models with disturbances like seam ends, faults, thinning, washouts and seam splitting is strongly influenced by the type of disturbance. Amplitudes of seam waves reflected from these disturbances strongly depend on the fault throw and the degree of thinning or washout. In some cases, conversion to higher modes can occur. Seam waves are not reflected from a seam splitting

disturbance. Thus a detection of seam splitting with reflected seam waves appears to be difficult.

FD computations for 3D models containing an ending tunnel parallel to the seam and a source beyond the heading face of the tunnel show, that seam waves are converted into Rayleigh waves at the tunnel face. They propagate along the surface of the tunnel and interfere with the seam waves propagating beside the tunnel. Polarisation analysis showed, that the elliptically polarised Rayleigh-type seam waves in the vertical-radial plane can be distinguished from Rayleigh tunnel waves propagating on the sidewall of the tunnel adjoining the coal layer with elliptical polarisation in the radial-transversal plane.