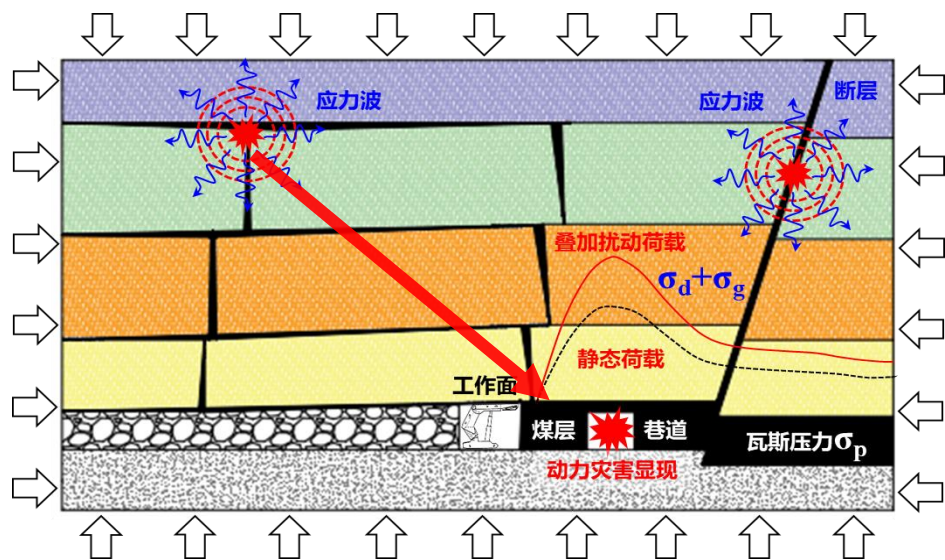


1

动静载叠加诱发冲击机理



- 动静载叠加诱冲力学模型
- 临界冲击应力的确定
- 动态应变率定义动静载
- 力、能的冲击矿压分类
- 动静载及其叠加作用效应

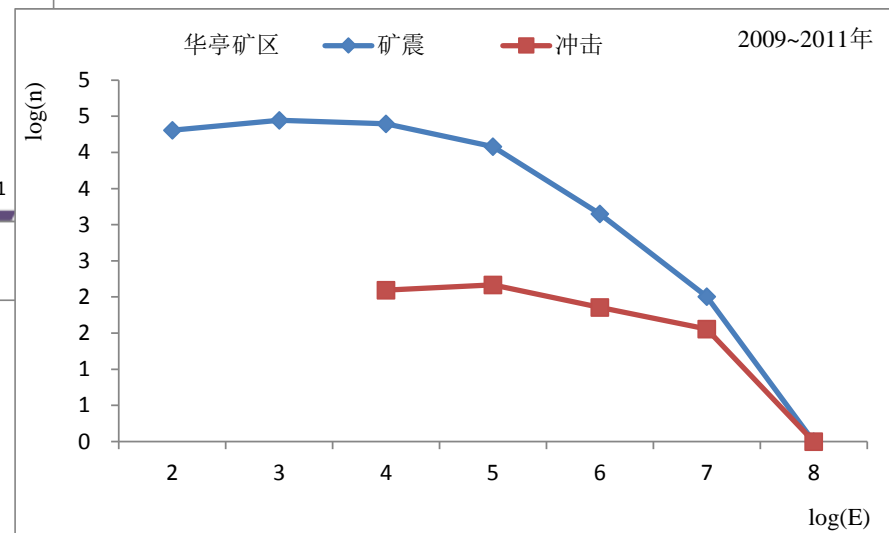
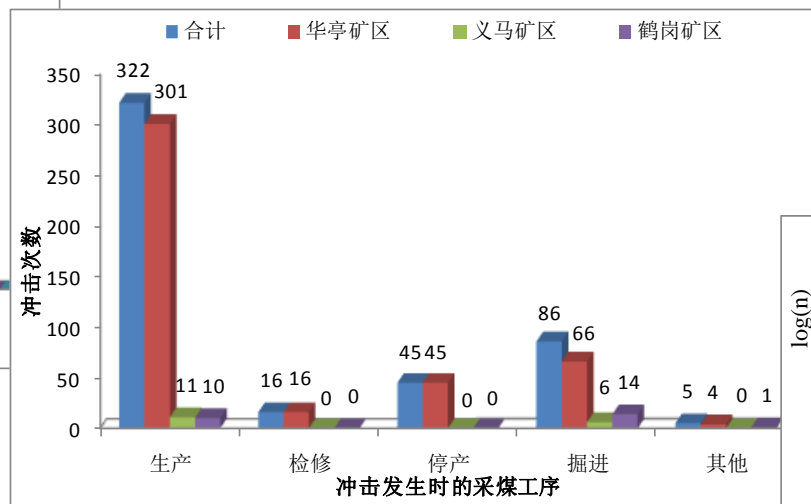
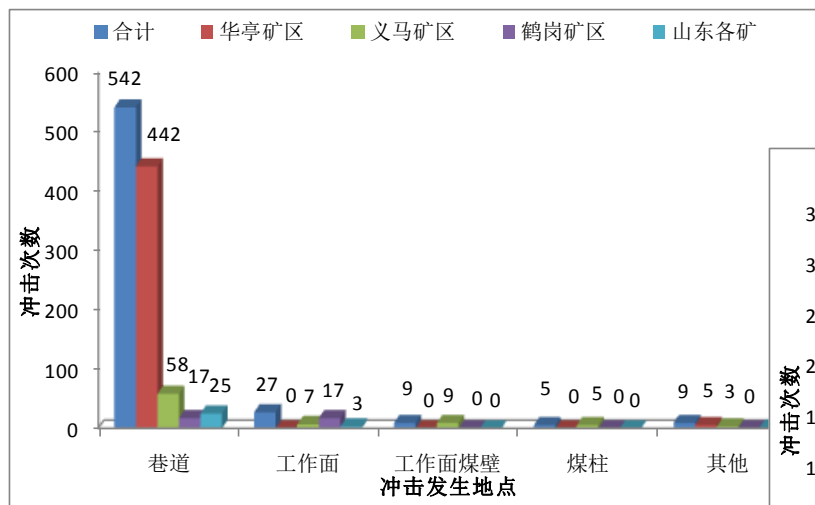
冲击矿压统计规律 (06-12)



State Key Laboratory
of Coal Resources and Safe M



- 冲击主要发生在巷道，占91%；
- 冲击主要发生在采煤和掘进工序中，分别为322次和86次。占86%；
- 华亭矿区矿震和冲击矿压频次 n 与能量 E 之间的关系。



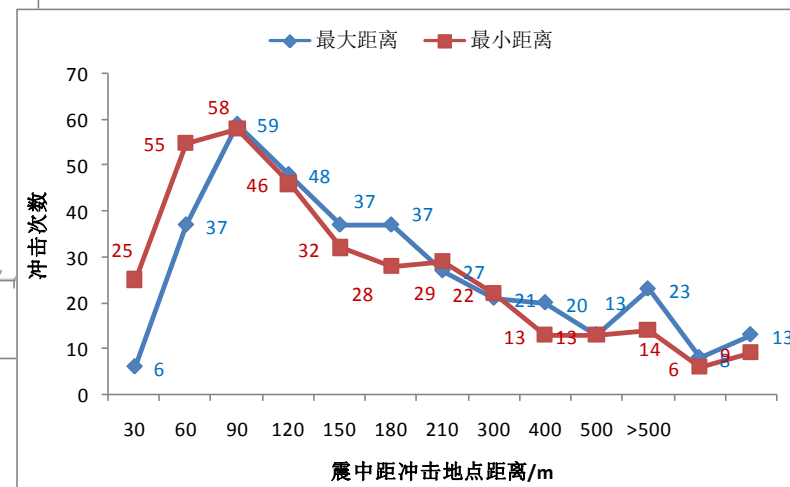
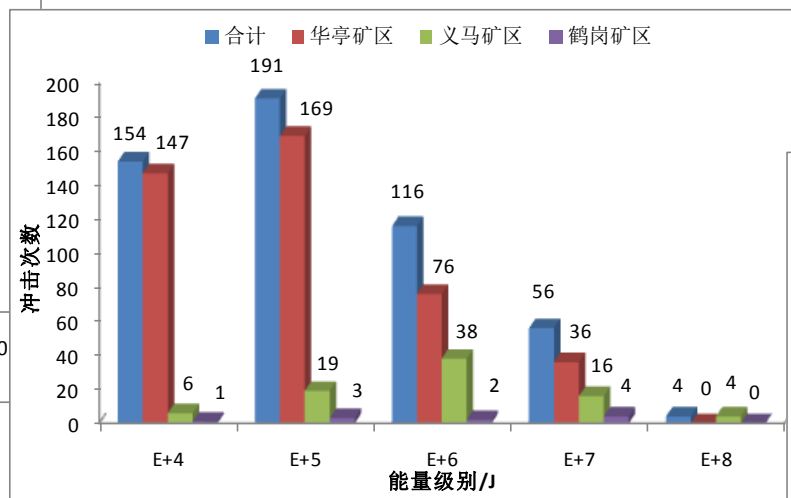
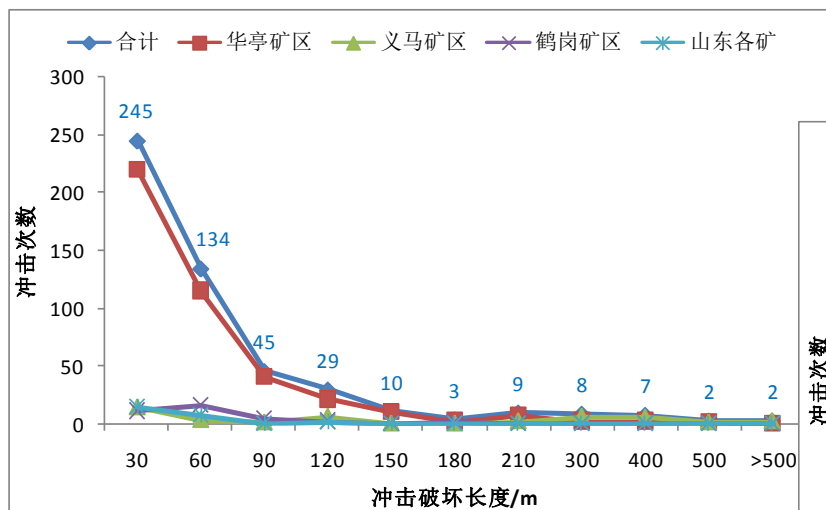
冲击矿压统计规律 (06-12)



State Key Laboratory
of Coal Resources and Safe M



- 冲击破坏长度主要在90m范围以内;
- 冲击能量主要: E4-E6J。其中华亭主要为E4-E5J, 义马主要为E6J。义马矿区有4次E8J的冲击;
- 震中距冲击地点最小距离主要分布在150m范围以内。



动静载叠加诱冲力学模型



State Key Laboratory
of Coal Resources and Safe M

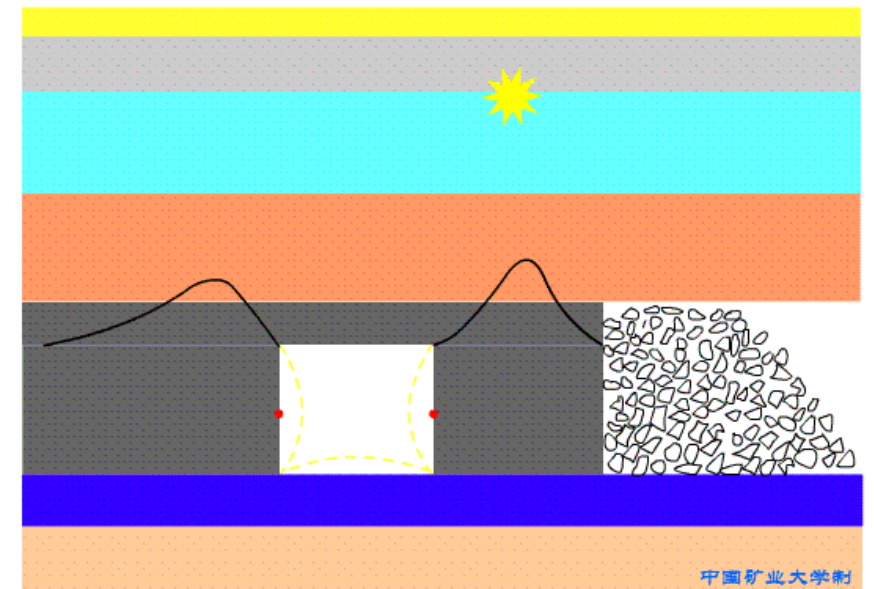
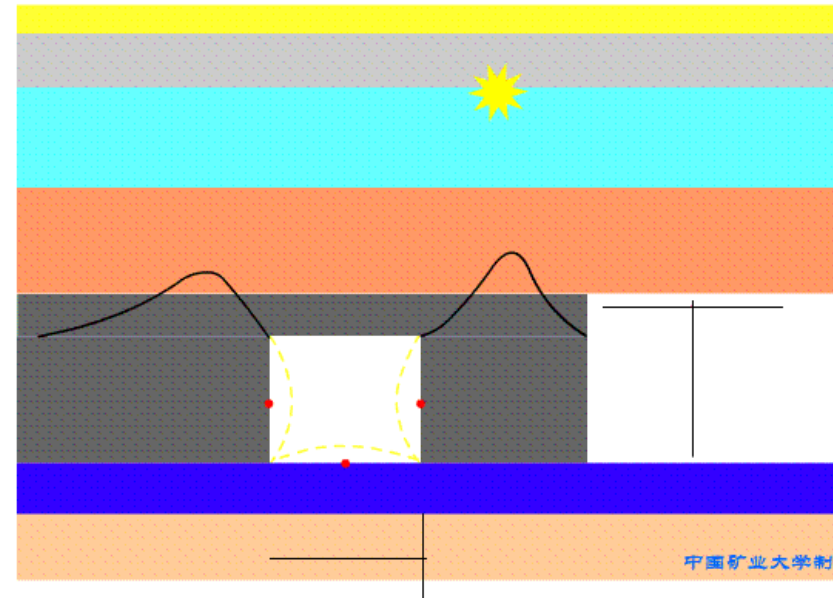
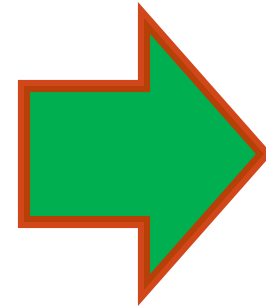
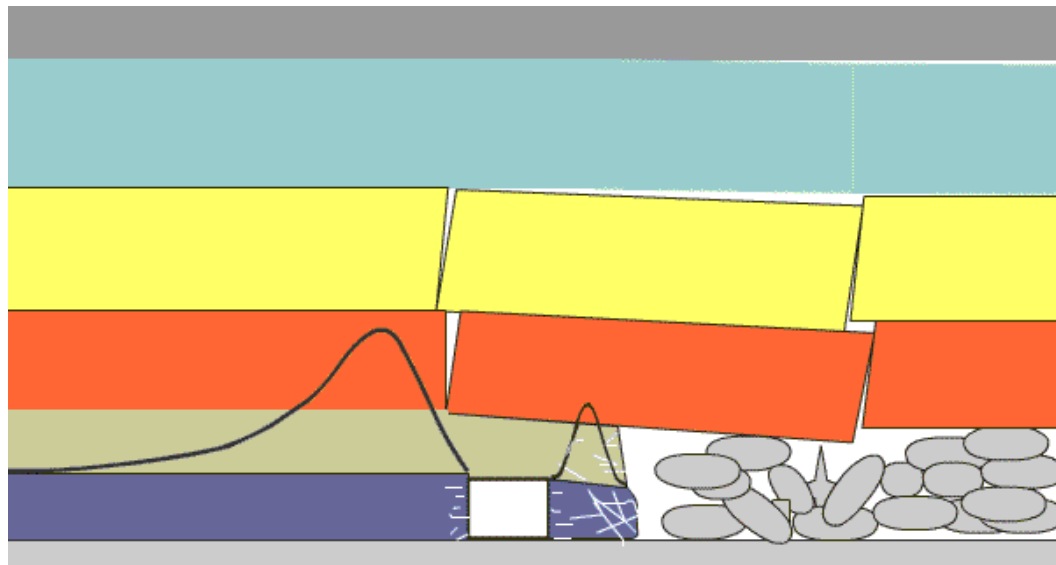


冲击的能量条件

$$\frac{dU_R}{dt} + \frac{dU_C}{dt} + \frac{dU_S}{dt} > \frac{dU_B}{dt}$$

冲击的应力条件-动静载

$$\sigma_j + \sigma_d \geq \sigma_{b \min}$$



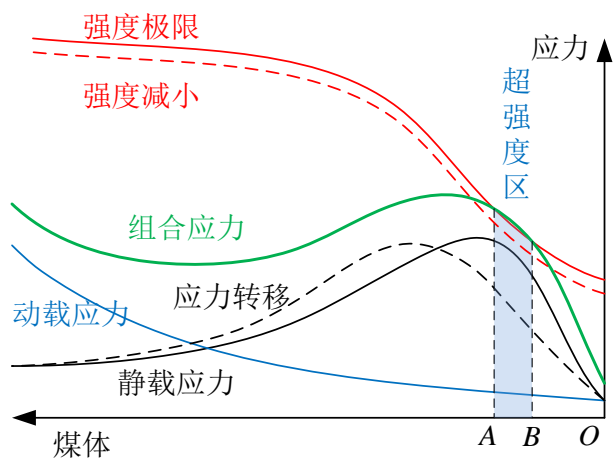
动静载叠加诱发冲击动力灾害机理

➤ 能量表达:
$$\frac{dU_R}{dt} + \frac{dU_C}{dt} + \frac{dU_S}{dt} > \frac{dU_B}{dt}$$

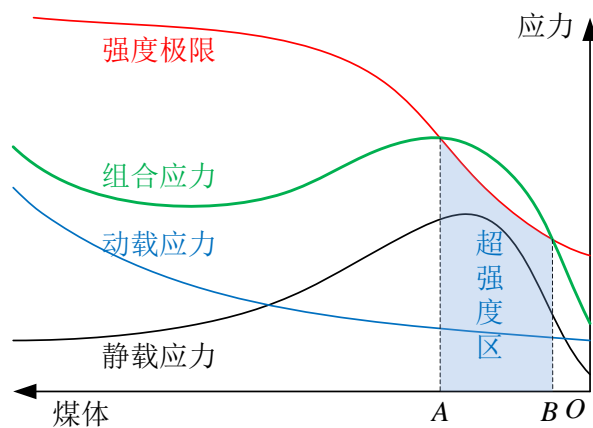
➤ 单向:
$$U = \frac{(\sigma_j + \sigma_d)^2}{2E} \quad U_{bmin} = \frac{\sigma_{bmin}^2}{2E}$$

$$\sigma_j + \sigma_d \geq \sigma_{bmin}$$

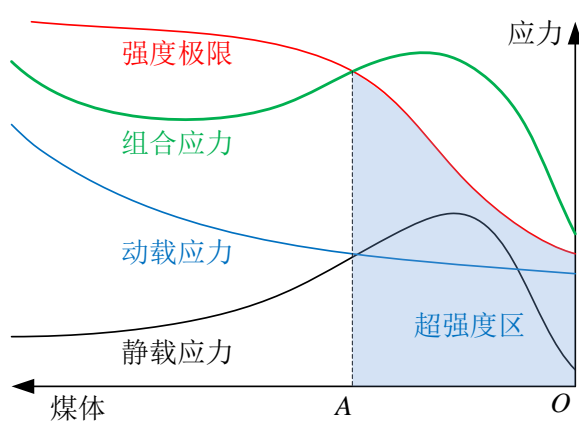
U_R —围岩中储存的能量;
 U_C —煤体中储存的能量
 U_S —矿震能量;
 U_B —冲击时消耗的能量
 U_{bmin} —动态破坏最小能量
 σ_j —静载应力
 σ_d —动载应力
 σ_{bmin} —临界应力



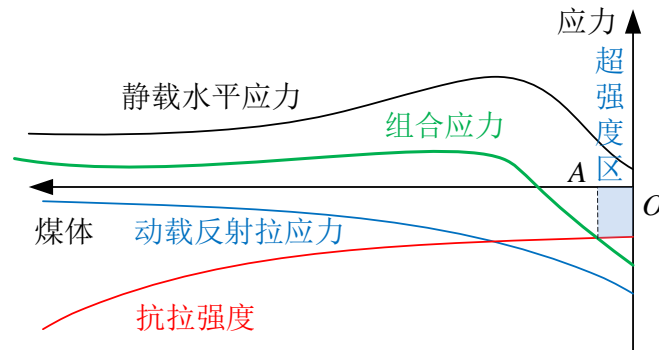
低应力扰动



动载扰动

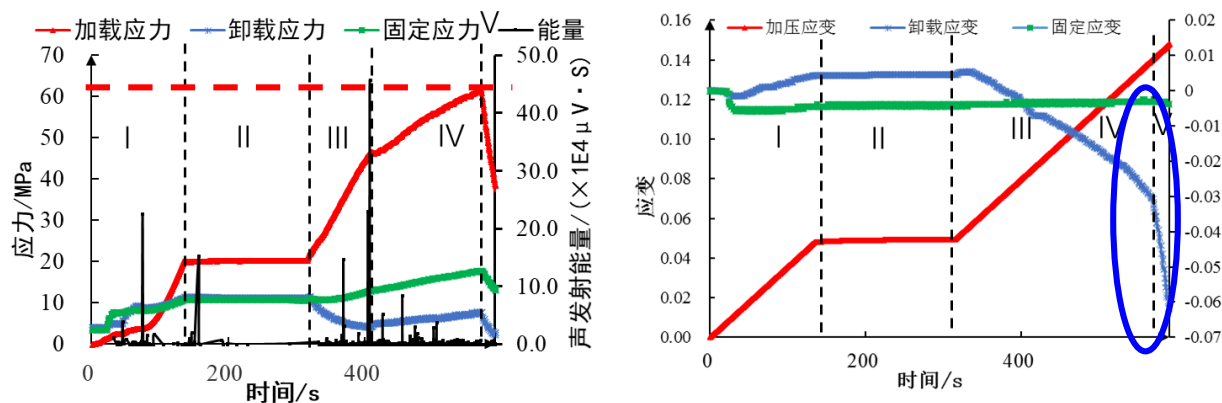


动静组合



反射拉伸

“加-卸” 路径下煤样冲击临界值



冲击需要满足两个条件

- 卸载速率条件:

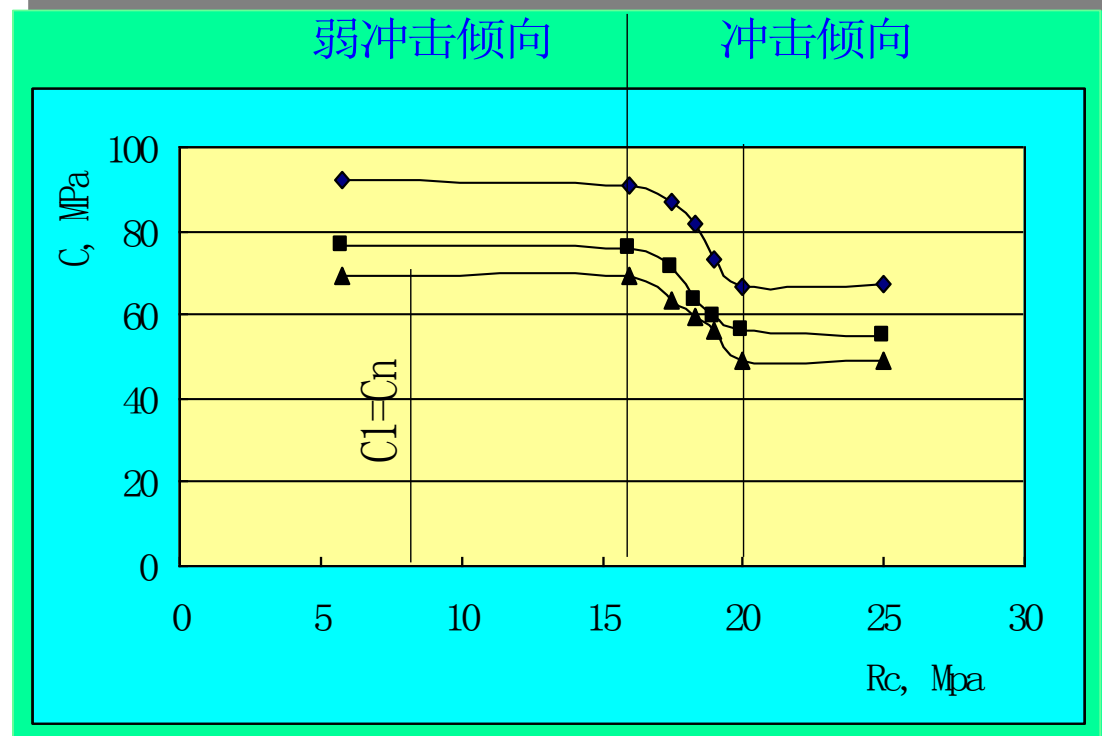
<1.128mm/min , 未冲击

>2.77mm/min , 冲击

- 应力条件:

<60MPa , 未冲击

>60MPa , 冲击



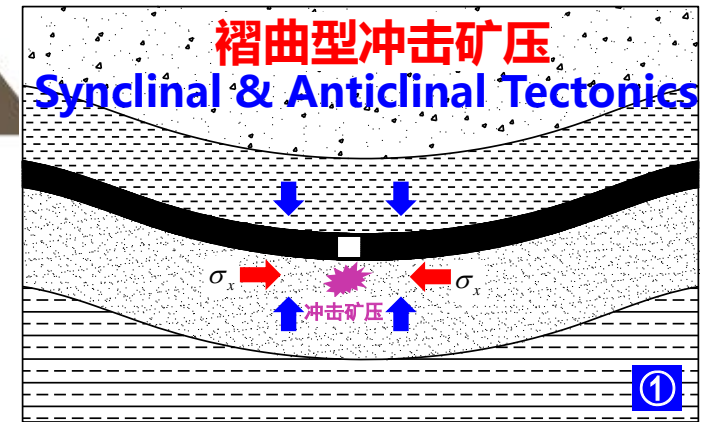
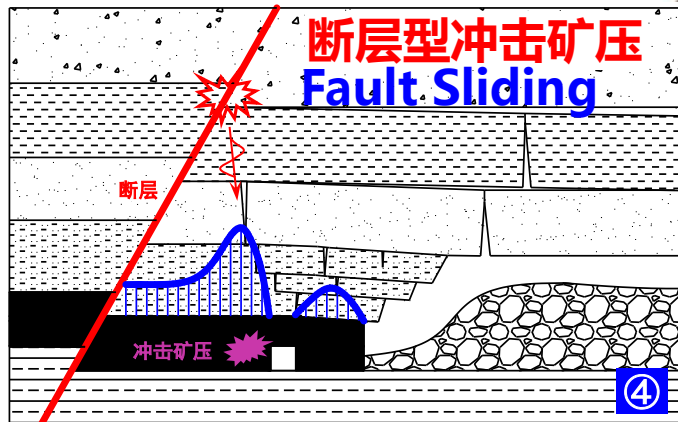
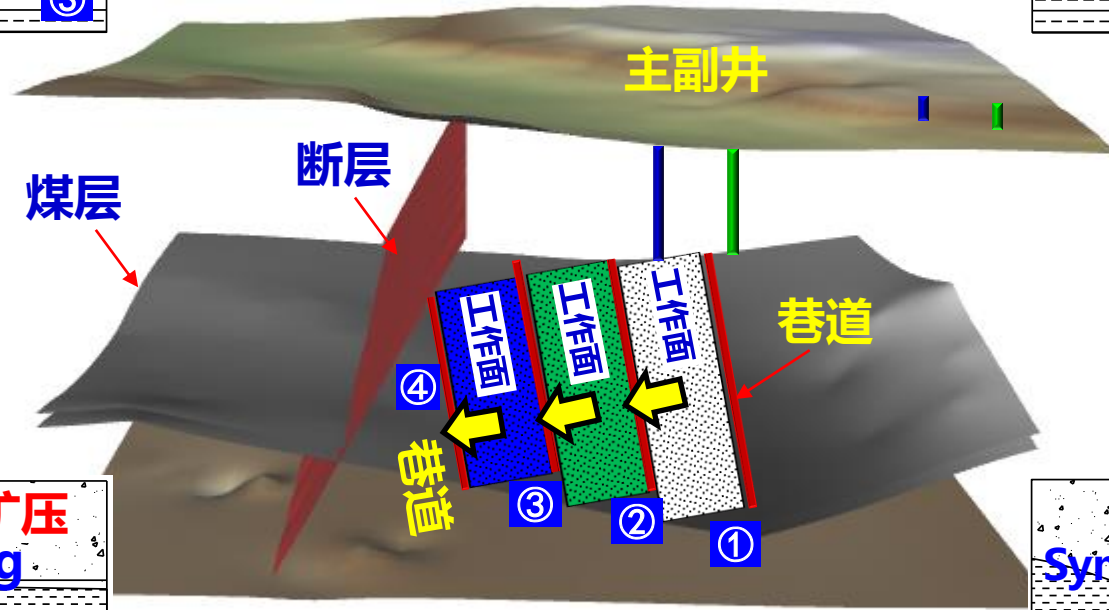
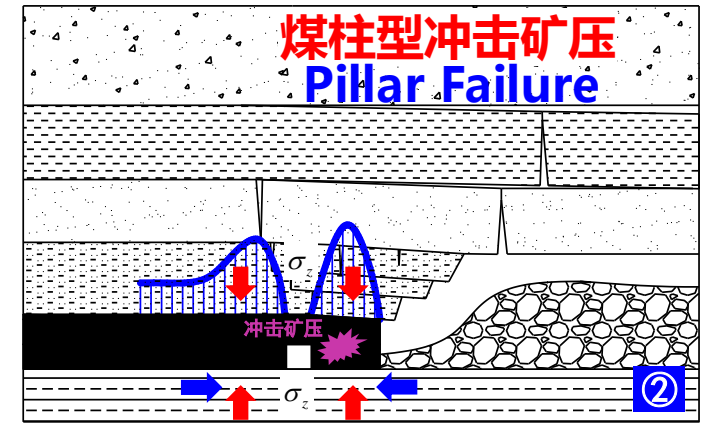
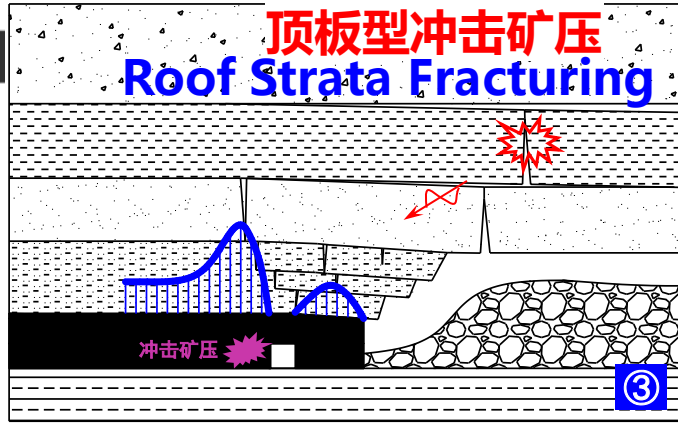
- 静载、动载的定义：
- 动态应变率：单位时间的应变量
 - 煤岩动力学实验：应变率大于 $10^{-3}/s$ 时，煤岩破坏与应变率具有较强的相关性；
 - 煤矿矿震动载：震源载荷应变率在 $10^{-3} \sim 10^{-1}s^{-1}$ 级之间。

应变率/ s^{-1}	载荷状态	载荷变化率/(MPa/s)	应力变化规律
$<10^{-5}$	静载	<0.1	基准载荷
$10^{-5} \sim 10^{-3}$	应力扰动	$0.1 \sim 10$	应力扰动
$>10^{-3}$	动载	>10	动态变化

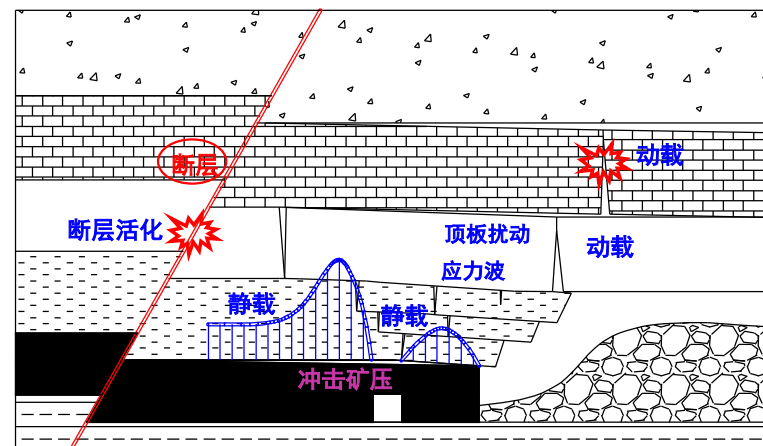
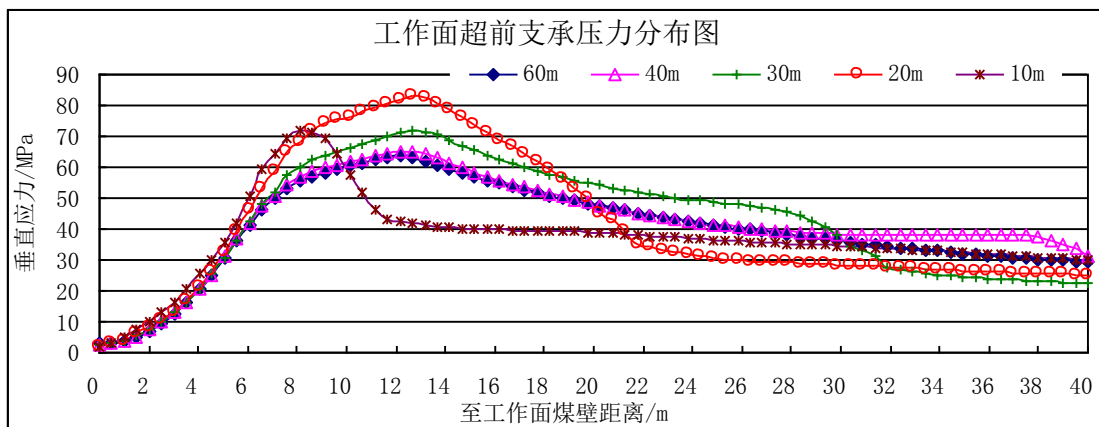


冲击矿压类型

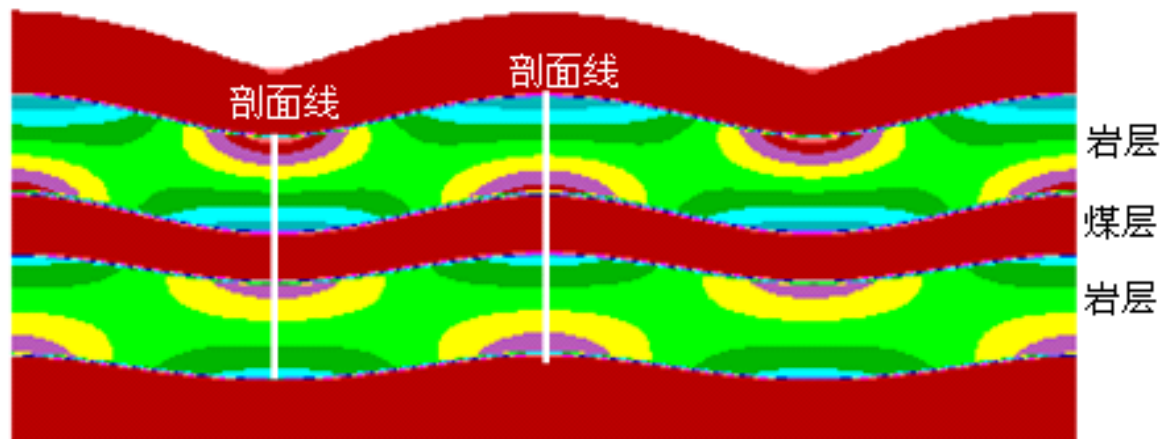
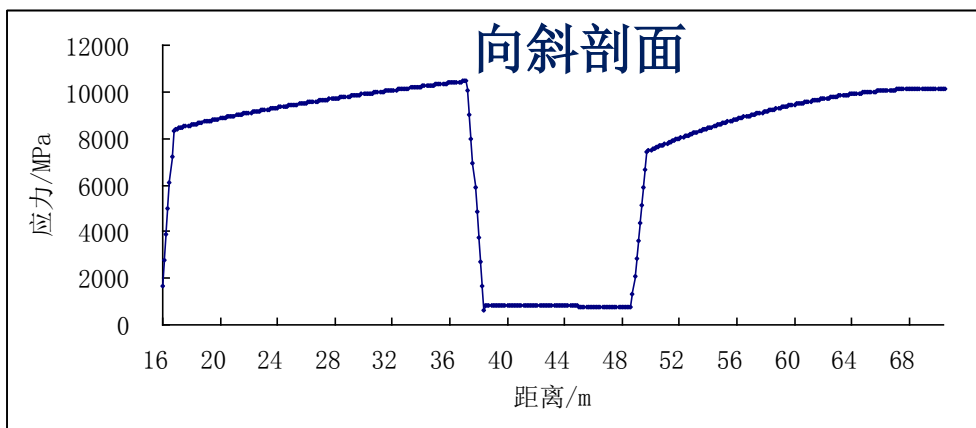
Classification of Coalburst



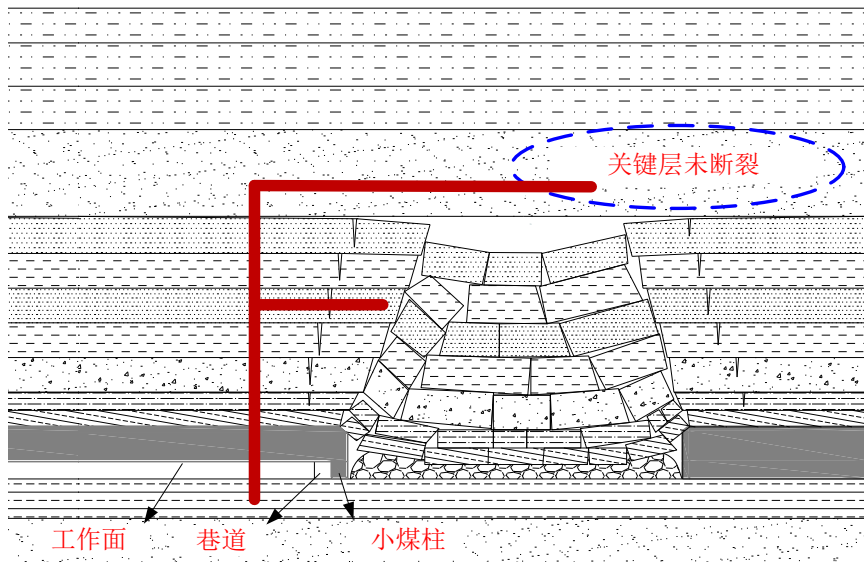
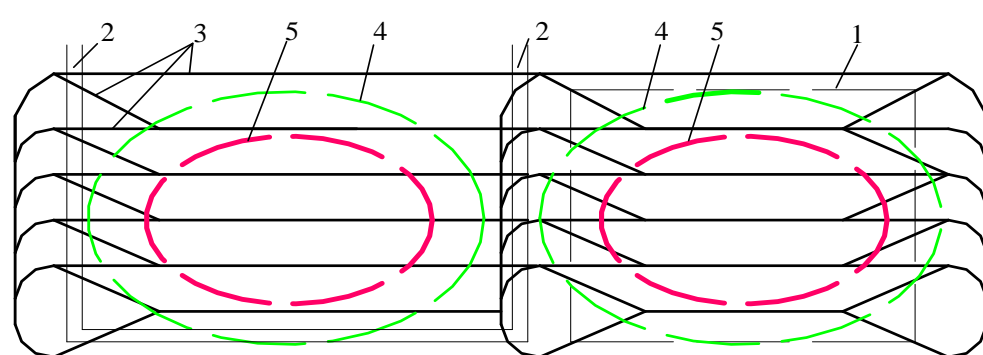
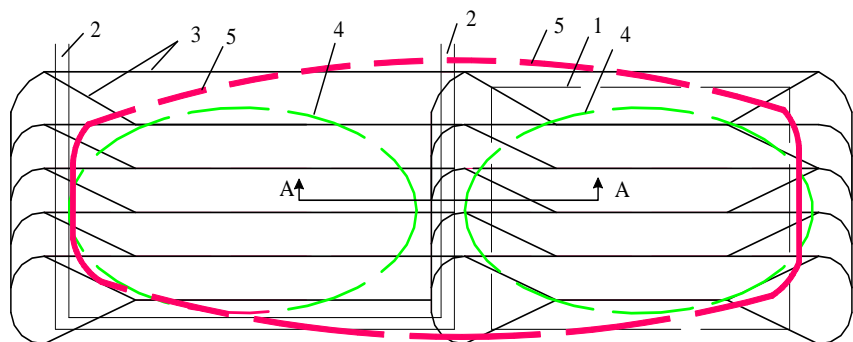
□ 断层附近的冲击规律



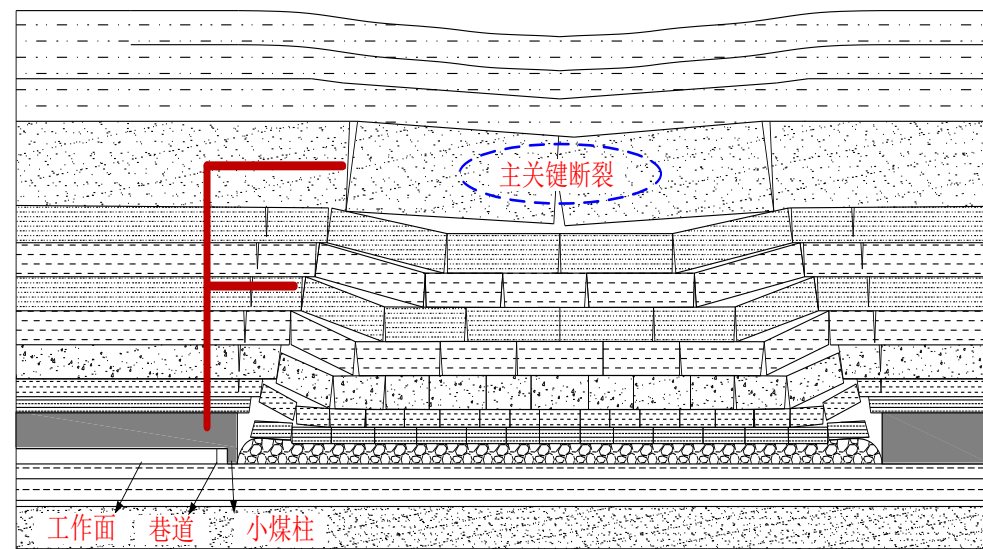
□ 褶皱构造附近的冲击规律



➤ 覆岩的 ⊗ —Π—F—T 型结构 (2012年)

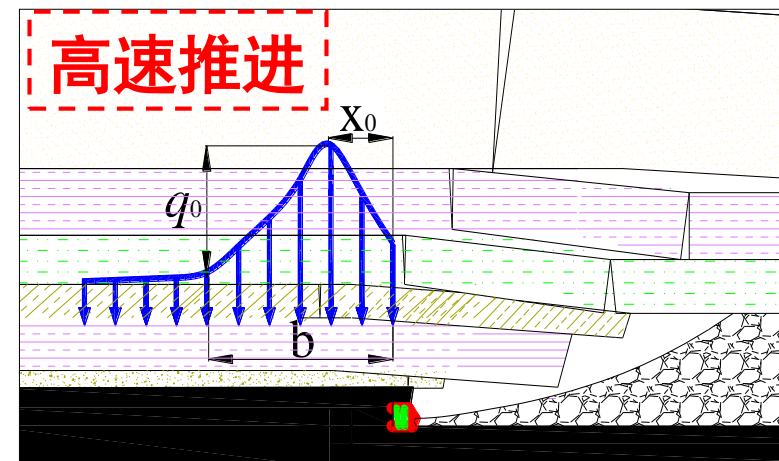
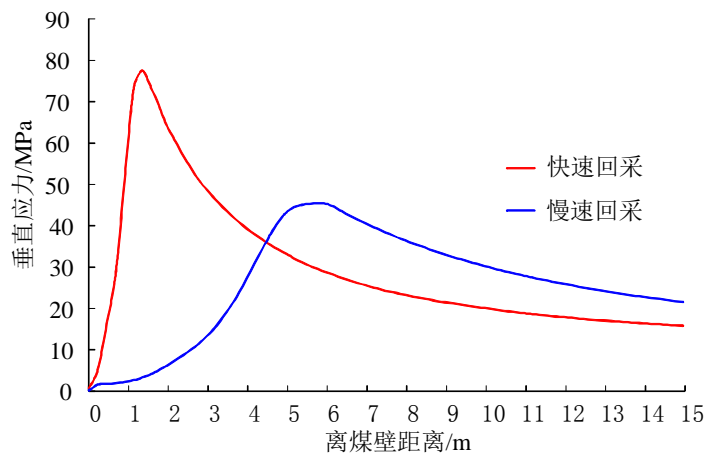
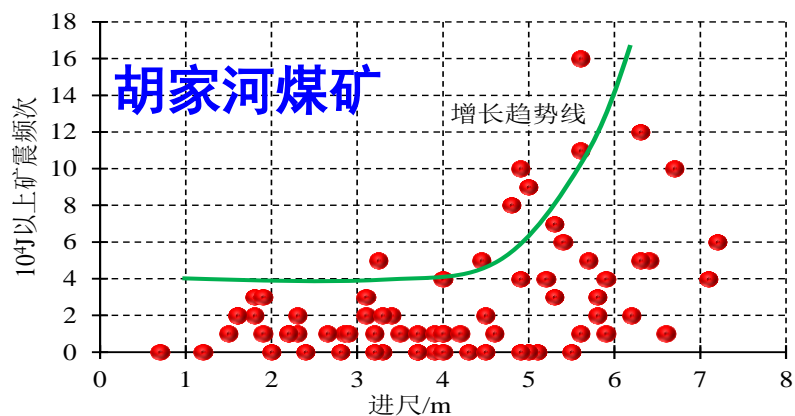


长臂F型结构

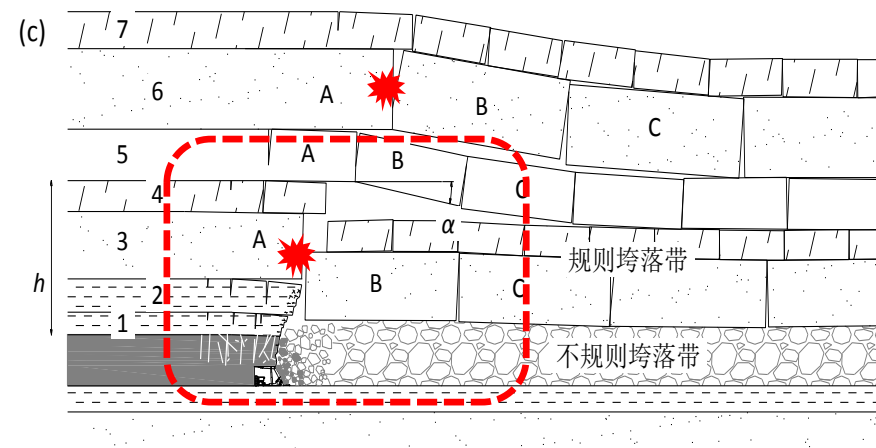
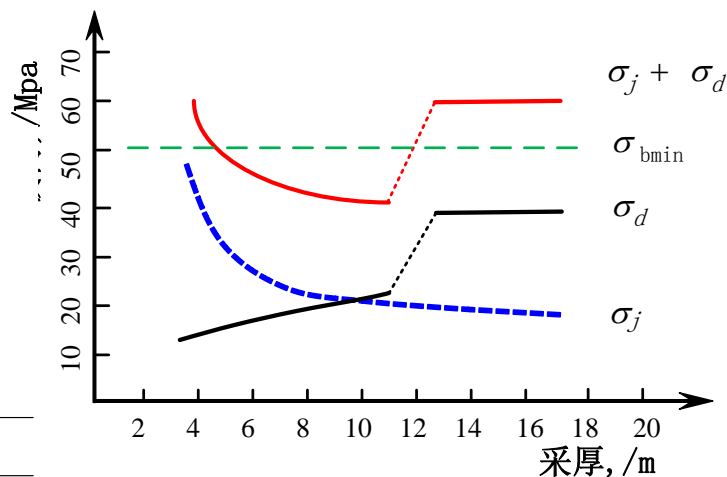
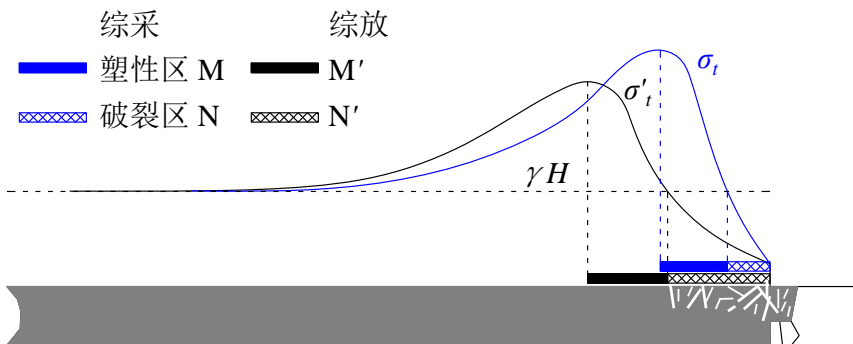


短臂F型结构

回采速度对冲击的控制作用



综放的降载减冲效应(2016)

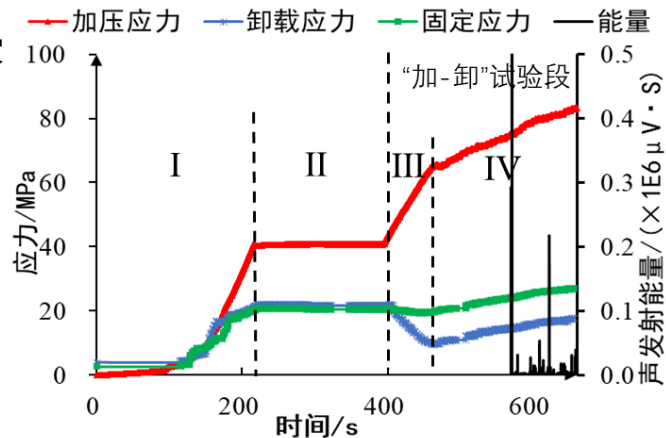


➤ 煤巷掘进应力路径转换及诱冲机制 (2019)

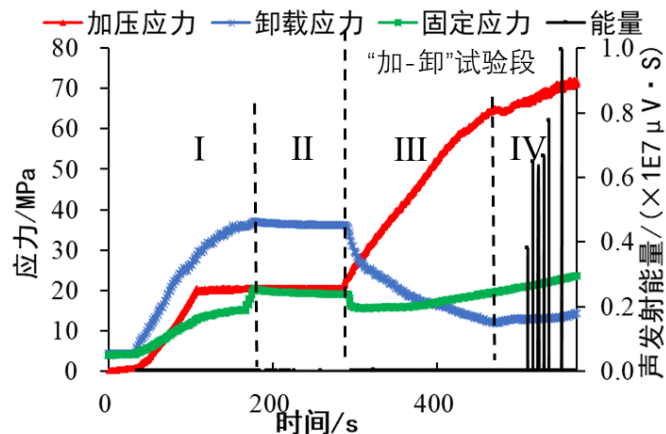
“加-卸” 应力路径转换



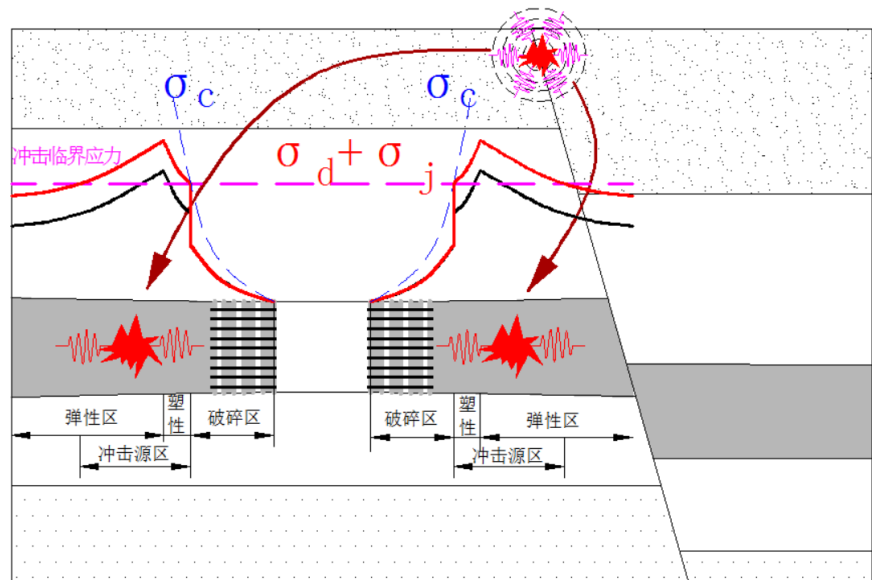
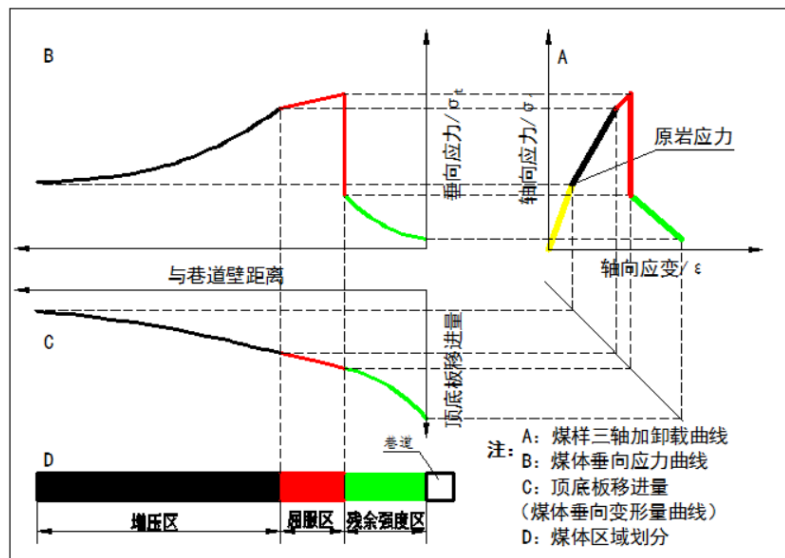
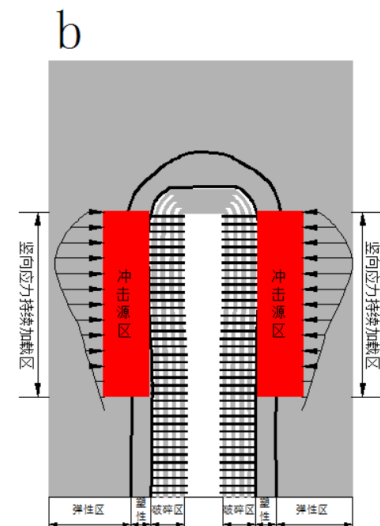
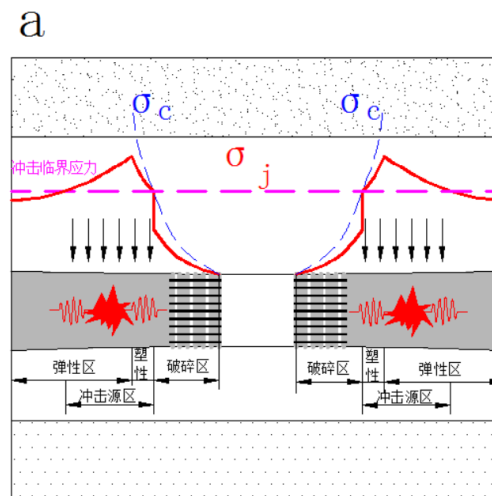
- 切向加载
- 径向卸载
- 走向应变不变”



高加载侧应力



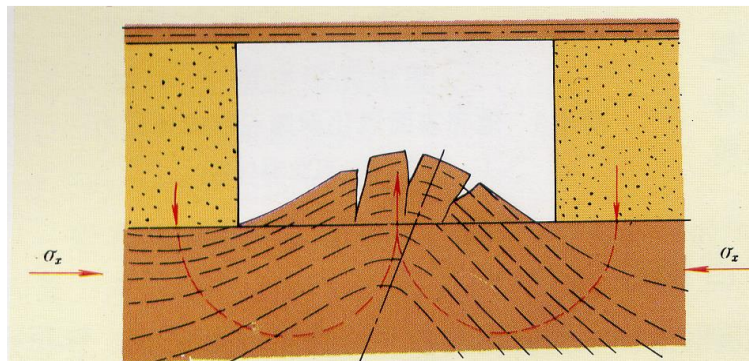
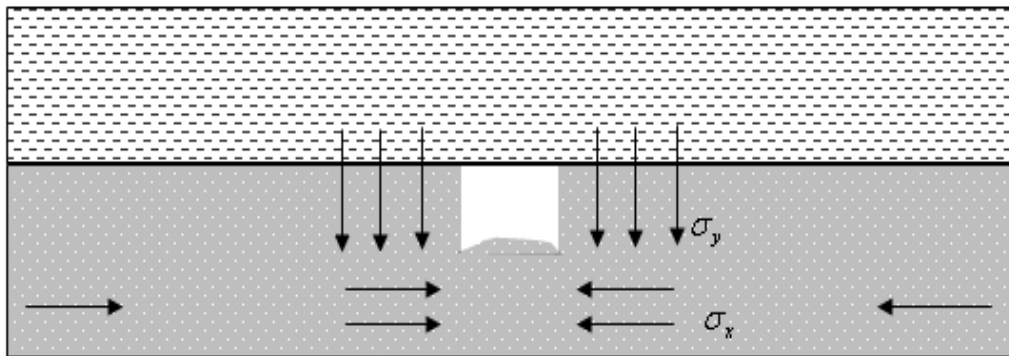
高卸载侧应力



注: A: 煤样三轴加卸载曲线
 B: 煤体垂向应力曲线
 C: 顶底板移进量 (煤体垂向变形量曲线)
 D: 煤体区域划分

注: A: 煤样三轴加卸载曲线
 B: 煤体垂向应力曲线
 C: 顶底板移进量 (煤体垂向变形量曲线)
 D: 煤体区域划分

➤ 巷道底板冲击判别模型



底板冲击矿压危险性系数

$$K_{fb} = k_1 k_2 \lambda K H \gamma_r \frac{B^2}{E h^2}$$

$$\sigma_x = k_2 \frac{\mu}{1 - \mu} \sigma_y$$

当 $K_{fb} \geq 1$ 时，巷道底板岩层发生破坏。

- ❑ 底板冲击矿压危险性系数与巷道埋深，水平构造应力，巷道宽度的平方，巨厚坚硬老顶影响系数成正比；
- ❑ 与弹模、巷道底板软弱层厚度的平方成反比。

λ 侧压系数；K，系数，取1.60~1.72； k_1 ，为坚硬老顶支承压力影响系数，为1； k_2 ，水平构造应力影响系数：