

山东临朐红丝石层中的古地震事件记录

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摘要:红丝石是产于山东临朐中奥陶统下部的一类具红色丝线状弯曲纹层的用于加工工艺品(砚台、笔筒等)的微晶碳酸盐岩。产有红丝石的这部分地层,厚约 60 m,被称为“红丝石层”。根据野外观测、室内鉴定及地震地质对比,从临朐红丝石层中识别出了具卷曲变形(包括塑性和半塑性变形)、环形纹层变形、微断裂(包括阶梯状和共轭微断裂)、震裂隙和震碎角砾等地震成因岩石构造的震积岩层。这些震积岩是中奥陶世古地震事件的记录,红丝石仅是古地震作用形成的一种常见的震积岩,由于在中奥陶世郯庐带内也有震积岩生成,因此认为这些地震记录是古郯庐带在中奥陶世强烈活动的证据。

关键词:古地震事件;震积岩;红丝石层;郯庐断裂带;临朐

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郯庐断裂带是中国东部一条规模最大的 NNE 向延伸的长期活动的断裂-地震带,在地史中,该断裂-地震带的多期强构造活动与地震事件发生时,也在同沉积盆地中形成多个震积事件层,从而留下丰富的地震记录。自从 20 世纪末乔秀夫等^[1-4]在该断裂-地震带地区识别出新元古界石旺庄组、九顶山组及望山组等震积事件层以来,地质工作者从该断裂地震带及其近区的寒武系馒头组碳酸盐岩、中生界南陵湖灰岩、古近系沙河街组湖泊沉积及朱壁店组冲积物中相继鉴别出了震积事件层^[5-10]。山东临朐位于郯庐断裂带中段(沂沭断裂带)的西侧,距郯庐断裂带约 30 km。最近,笔者也从临朐中奥陶统红丝石层中识别出了地震事件记录,它们是一系列震积岩与震积构造(地震沉积构造的简称)。笔者阐述了这些震积岩与震积构造的特征,认为它们是古郯庐带在中奥陶世活动的证据。

1 地质概况

红丝石的岩石学名称为红褐色-黄褐色微细纹层状铁质微晶灰岩、白云岩、泥云岩及泥灰岩,因其具有红(紫)色与灰黄色相间的丝状纹层理而得名,主要由方解石(或白云石)、褐铁矿及泥质组成,其中的红或紫色纹理含较高的褐铁矿。红丝石是加工砚台、笔筒及笔架等石质工艺品的矿产资

源,发育红丝石的这部分地层被称为“红丝石层”。由于红丝石的结构细腻,纹层理弯曲多变,致使红丝石质工艺品表面呈现各种典雅而美妙的图案,从而得到古今中外名人的珍爱^[11]。红丝石主要产于鲁中临朐县冶源及青州市大黑山等地。青州大黑山一带的红丝石只有一层,厚度仅 0.5 m 左右,产于中奥陶统马家沟组东黄山段的底部,始采于宋代,不久枯竭,所以现在的红丝石产地指临朐冶源镇一带(图 1)。

冶源在临朐县城以南约 10 km 处,附近出露的地层为寒武系、奥陶系及第四系。寒武系主要由碳酸盐岩组成,下部夹页岩与细砂岩。奥陶系由下奥陶统三山子组与中奥陶统马家沟组碳酸盐岩组成,马家沟组与三山子组呈平行不整合接触关系。马家沟组自下而上分为东黄山段、北庵庄段、土峪段、五阳山段、阁庄段及八陡段 6 个岩性段,各段间呈整合接触关系;下部两个段属大湾阶,其余 4 个段属达瑞维尔阶^[12,13];其中的东黄山段、土峪组和阁庄段,每段厚度为 30~60 m,主要岩性为薄层-中厚层白云岩、泥云岩及泥灰岩,属潮坪-潟湖相沉积,岩层发育纹层状及角砾状构造,角砾多呈棱角状-次棱角状;其余 3 个岩性段主要由开阔台地相灰色厚层灰岩组成,每段厚度一般为 90~300 m^[13]。

红丝石产在东黄山段至北庵庄段的底部,其中,东黄山段(厚 54 m)产红丝石达 6 层,每层厚度 0.2~1.0 m;北庵庄段

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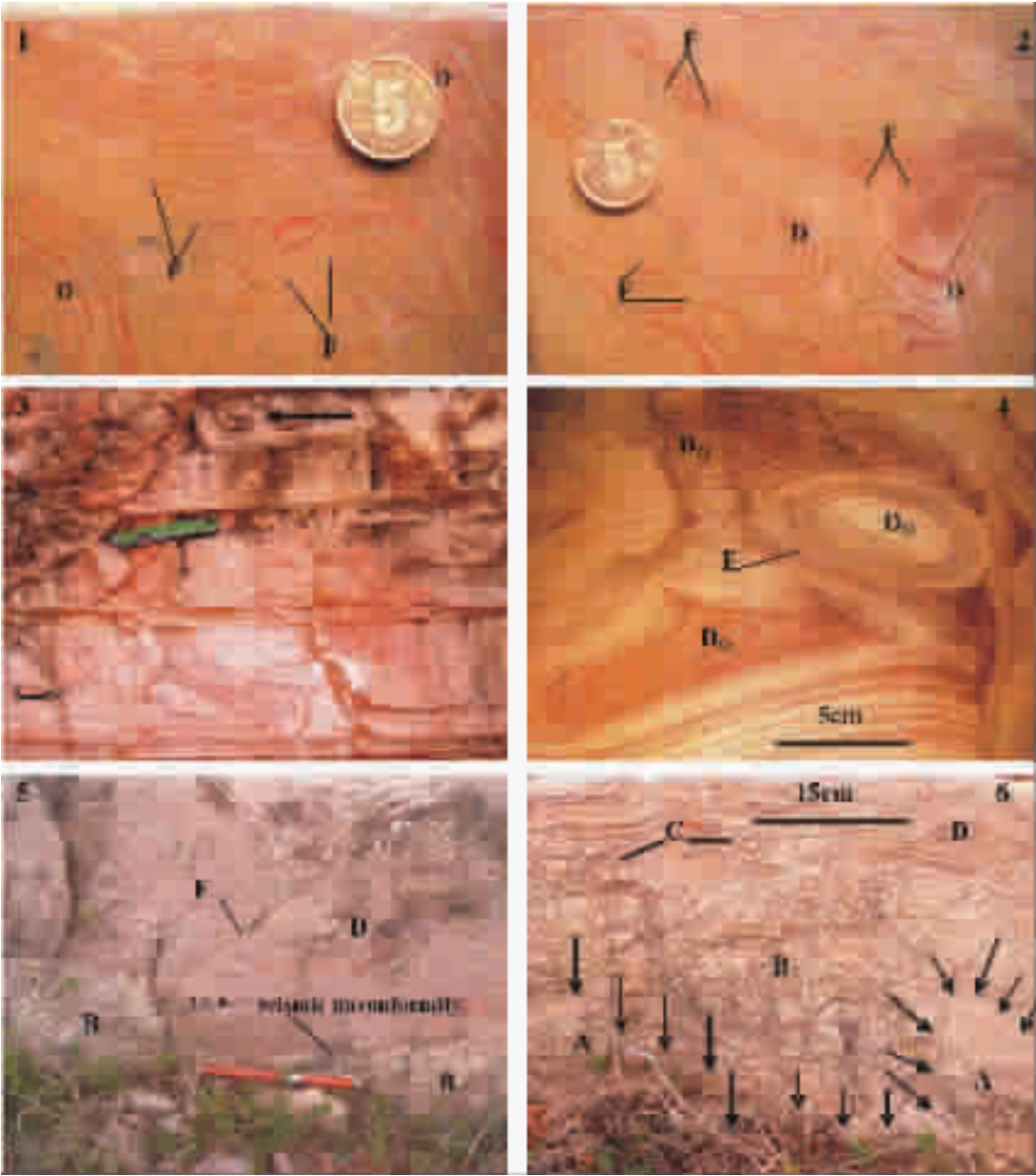


图 2 临朐红丝石层中的震积构造与震积岩

1—塑性卷曲变形构造(D)与阶梯状微断裂(F)红丝石磨光面; 2—塑性卷曲变形构造(D)及共轭微断裂(F)红丝石磨光面;
3—在几层近水平岩层中,纹层可与层面相交、平行(箭头处),但均不造成岩层产状变化;4—红丝石磨光面上的环形纹层变形构造(DO)与微断
裂(F)共生红丝石磨光面; 5—半塑性卷曲变形构造(D)及微断裂(F),它们以震积不整合覆于震裂岩(B)之上;
6—脆性震积岩:震碎角砾岩(C)及具密集震裂隙的震裂岩(B),它们与下伏的未震岩层(A)呈渐变关系(箭头所指处)

Fig.2 Seismic structures and seismites in the red-silk stone bed of Linqu

1—Plastic curl deformation structure(D)and ladder microfracture (F)(on the polished surface of red-silk stone; 2—Plastic curl deformation structure (D)and conjugated microfracture(F) on the polished surface of red-silk stone; 3—Laminations diagonal or parallel (arrow position)to bedding planes in several subhorizontal layers, which does not cause the change in attitude of strata;4—Circular-lamination structure (DO) coexisting with microfractures (F) on the polished surface of red-silk stone; 5—Semi-plastic curl deformation structure (D) cut by a microfracture(F), which overlies a shattered layer (B) with a seismic unconformity;6—Friable seismites: seismic breccias(C)and shattered layer with dense cracks(B), which have a gradually gradational relationship with the underlying unshocked layer(place of arrowheads)

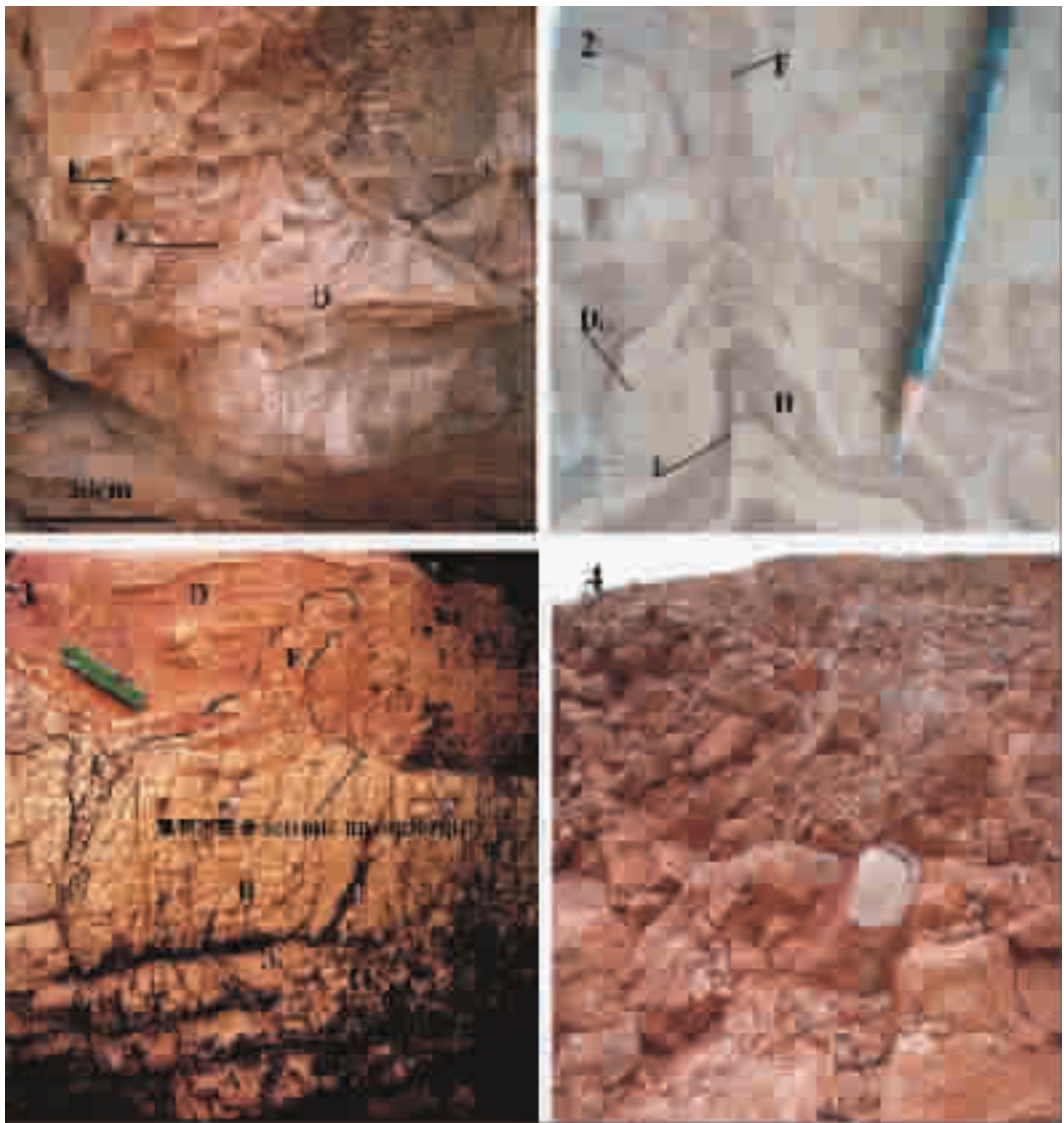


图 3 沂水杨庄镇中奥陶统碳酸盐岩中的震积构造与震积岩

1—塑性卷曲变形构造(D)与阶梯状微断裂(F);2—塑性卷曲变形(D)和环形纹层变形(DO)与共生微断裂(F)岩石磨光面;
3—自下而上为:未震岩层(A),具密集震裂隙的震裂岩(B),充填震裂缝的震碎角砾岩(C),与震裂岩相连的震起构造(E)及具半塑性卷曲变形的震褶岩(D);4—与震褶岩伴生的震浊积岩,由具粒序层理、砾石滑动刻痕及细小砾石流动构造的泥质砾岩组成

Fig.3 Seismic structure and seismites in the Middle Ordovician carbonates rocks at Yangzhuang Township, Yishui

1—Plastic curl deformation (D) and ladder microfracture (F);2—Plastic curl deformation (D)and circular-lamination structure(DO)with their associated microfractures on the polished surface of rock specimens;3—From below upward: unshocked layer(A), shattered layer with dense shocked cracks(B), seismic breccias filling in seismic fissures (C), upward-moving structure of breccias (E)caused by earthquake in connection with the shattered layer and seismic folded layer with semi-plastic curl deformation(D);4—Seismic turbidite coexisting with seismic folded layer, which consists of muddy conglomerate with graded bedding, slip scratches on gravels and flow structure of fine gravels

属层内同沉积断裂,规模细小,断面内充填微晶泥灰质或泥质,反映形成时沉积物处于未固化状态,而构造小断裂的规模较粗大,往往穿切数层岩层,其断面内充填着灰白色较粗的结晶方解石等,图 2—2 中硬币处较宽者为一条由结晶方解石脉充填的构造小断裂。

Seilacher A.^[19] 在对比了现代地震与古地震作用的沉积物后,便提出了微断裂与微褶纹理(卷曲变形构造)两种层内构造作为识别震积岩的标志;中国学者所发现、研究的许多震积事件地层都发育地震微断裂^[1-5,8-10,15,19-23]且与临朐红丝石层中的微断裂特征相同。它们属地震对先成沉积物破坏的遗

迹。根据地震微断裂切断卷曲纹层的特征分析,其形成序次略晚于卷曲变形构造。

2.3 震裂隙及震碎角砾构造

震裂隙和震碎角砾构造是地震对先成固化沉积物震裂、震碎而形成的震积岩构造,具震裂隙、震碎角砾构造的岩石分别为震裂岩及震碎角砾岩(图2—5~6中的B、C),属脆性震积岩^[4]。它们发育在卷曲变形构造层之下,并与卷曲变形构造层(图2—5~6中的D)呈震积不整合^[20~22]接触。

震裂岩(图2—5~6中的B)具密集分布的震裂隙,震裂隙长3~10 cm,它们虽然已将先成岩层破坏,但岩层仍基本保持着整体形态。震裂岩的厚度不稳定,与未受地震影响的岩石没有明晰的界线,呈渐变关系,相当于梁定益等^[18]建立的地震扰动序列中的脆性变形韵律层段,不同于乔秀夫等^[1~4]所阐述液化序列震裂岩,笔者所述的震裂岩层以发育密集的脆性震裂隙为特征。

震碎角砾岩中的角砾呈棱角状,其物质成分与震裂岩相同,分布不均匀,纵向上震碎角砾岩(图2—6中的C)发育在震裂岩之上,部分被卷入震褶岩(图2—6中的D)中。显然,震碎角砾岩是固化岩层被震碎解离成棱角状的脆性角砾、再经泥质—泥灰质胶结而成。

记录古地震事件的临朐红丝石层中的震积岩不是孤立存在的,笔者发现郯庐断裂带内的沂水县杨庄镇(图1)东部的中奥陶统马家沟组东黄山段—土峪段中也发育震积岩层(图3),只因那里的岩层过于破碎,不适合用于加工工艺品。在那里除发育上述几种震积岩之外,还发育震浊积岩,根据震浊积岩特征(图3~4),可能是地震诱发滑动与流动作用而形成。

3 地震事件的时代及研究意义

临朐红丝石层所处的地层层位属中奥陶统大湾阶的下部^[11~13],因此,红丝石层所记录的地震事件发生于中奥陶世早期,距今约 $(471.8 \pm 1.6) \text{ Ma}$ ^[24]。沂沭断裂带及其附近的奥陶系中发育震积事件层,这使该地区奥陶纪地层的研究程度得到了提高。

红丝石层发育在郯庐断裂带附近,在郯庐断裂带内的相同层位也发育震积岩,这表明该地区乃至郯庐断裂带的中奥陶纪存在着一个地震活跃期,它大致与华北地台震旦纪—早古生代古地震节律^[24]中490 Ma左右的活跃期相对应,这为古郯庐带^[1~4]的存在提供了新资料。

从红丝石层中鉴别处一系列震积构造,不仅使红丝石这种工艺品材料矿产的成因得到了客观、合理的解释;也表明地震灾变事件是“一把双刃剑”,地震一方面使地壳发生快速震动而引起破坏作用,另一方面对某些矿产的形成产生了积极作用,这是值得深入研究的新课题。

另外,有必要说明一点:由于红丝石层中岩石普遍含有泥质,泥质具有较大的粘聚力,根据含有一定量泥质的水饱和砂受强震不发生液化或难以液化的原理^[24],这可能是红丝

石层中不发育液化微晶碳酸盐岩脉的原因之一,即饱和含泥质颗粒较高的碳酸盐岩沉积颗粒,受泥质粘聚力作用不发生液化;另一原因可能是古生代以来地震强度大多较前震旦纪地震强度有所降低,使古生代以来的碳酸盐岩软沉积物难以形成液化脉构造。

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Records of paleoseismic events in the red-silk stone bed in Linqu, Shandong

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Abstract: Red-silk stone is a kind of microcrystalline carbonate rocks with red silk thread-like curled laminations used for carving stone handicrafts (ink slabs, brush pots etc.), which occurs in the lower part of the Middle Ordovician in Linqu, Shandong. The portion of strata containing red-silk stone, about 60 m thick, is named “red silk stone bed”. Based on field observation, lab examination correlation of seismic structures, seismite layers with seismogenetic structures such as curl deformation (including plastic and semi-plastic deformations), circular laminations, microfractures (including ladder and conjugated ones), vibration fissures and shattered breccia are recognized in the red-silk stone bed. These seismites are records of Middle Ordovician paleoseismic events. Red-silk stone is only one of common seismites formed by paleoseismism. As seismites also formed in the Middle Ordovician Tanlu zone, it is considered that these seismic records are evidence of the intense tectonic activity of the Paleo-Tanlu fault at that time.

Key words: paleoseismic event; seismite; red-silk stone bed; Tanlu fault zone; Linqu

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