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The coals at the P/T boundary in SW China: their petrology, mineralogy and isotope geochemistry

Shao, L. -Y.[1], Wang, J.[1], Hou, H. -H.[1], Wang, H.[1], Large, D. J.[2], Wignall, P. B.[3]

[1]College of Geosciences and Survey Engineering, China University of Mining and Technology (Beijing), D11 Xueyuan Road, Beijing, China, 100083. (ShaoL@cumtb.edu.cn)
[2] Faculty of Engineering, University of Nottingham, UK, NG7 2RD. (david.large@nottingham.ac.uk)
[3] School of Earth and Environment, University of Leeds, UK, LS2 9JT (P.B.Wignall@leeds.ac.uk)

Non-marine terrestrial coal measures of the Late Permian are developed in the Xuanwei area of Yunan Province (SW China). The C_1 coal, which contains the B_1, B_2, B_3 sub-coal seams in descending order, lies in the uppermost Xuanwei Formation (Lopingian). The proximal nature of the C_1 coal to the Permian - Triassic Boundary (PTB) has been established by a combination of biostratigraphic, geochemical and lithological evidences. For instance, above C_1 no coal seam was found, and like elsewhere in the world, it indicates the beginning of the "coal gap" in the early Triassic. For these latest Permian coals, we have investigated the coal petrology, mineralogy, organic carbon isotopes, organic sulphur isotopes, as well as heavy metal compositions.

Coal petrology studies have revealed the upward increasing trend of the inertinite abundance in the latest Permian coals, and this could imply that the Late Permian peatland suffered from frequent wildfires. Since ignition and burning depend on sufficient oxygen, a model-based calculation suggests that the O_2 levels at the latest Permian near the PTB could reach 28%. Quartz is the dominant mineral in the C_1 coal, while kaolinite is the dominant mineral in roofs, floors and partings of the C_1 coal seam. Hexagonal β-quartz in desmocollinite, abundant perfect hexagonal bipyramid quartz and sharp bipyramid anatase show that the C_1 coal was also influenced by volcanic activity during peat swamp development.

Different sulphur fractions of low sulphur (average 0.11%) coals from the latest Permian coal in Xuanwei area were analyzed isotopically at a high vertical resolution. S_{org} (organic sulphur) accounts for 87% of the total sulphur content on average, while S_{py} (pyritic sulphur) is very low, accounting for 13%, and relatively constant throughout the profile except for some insignificant additions in clay-rich layers. The $\delta^{34}S_{org}$ values have a relatively narrow range, from +1.5‰ to +7.6 ‰, and the stratigraphically lower coal (B_3) has $\delta^{34}S_{org}$ values around +4 ‰ while the stratigraphically higher coal (B_2), which is closer to the PTB, has clearly higher $\delta^{34}S_{org}$ values, ranging from +5.3 to +7.6 ‰. This change is most likely due to increased marine sulphate aerosol inputs into the coal-forming peatland, caused by coastline retreat during Late Permian transgression.

The organic carbon isotopes of these latest Permian coals were analyzed, and the results showed that the carbon isotope profile depicts an upward lightening trend throughout the whole Late Permian (Lopingian), and in the uppermost few seams, a negative excursion with magnitude of about -5.0‰ (-25‰ to -30‰) is evident. These phenomena are consistent with the observations from other reported marine and terrestrial PTB sections. It has been generally accepted that the PTB event was a protracted

event with various causes including volcanic eruption, release of methane, baking or burning the coal measures in the major coal basins. However, coal is the product of the peatland, which is the direct evidence of the terrestrial ecosystem. Coal persisted after the onset of the negative excursion, suggesting the causes of the carbon cycle perturbation did not wipe out the terrestrial productivity immediately. Comparatively, the major marine fauna extinction started at the beginning of the carbon isotopic excursion near the PTB in marine sections. It is thus suggested that terrestrial ecosystems were more resilient towards the carbon cycle perturbation.