Supplementary File 1 for Uchman A., Hanken N.-M., Nielsen J.P., Grundvåg S.-A. & Piasecki S. 2016. Depositional environment, ichnological features and oxygenation of Permian to earliest Triassic marine sediments in central Spitsbergen, Svalbard. *Polar Research 35*. Correspondence: Alfred Uchman, Jagiellonian University, Institute of Geological Sciences, Oleandry Str. 2a, PL-30-063, Kraków, Poland. E-mail: alfred.uchman@uj.edu.pl

Material and methods

This study is based on field observations carried out over a four-week period in the summer of 2007, during which two main profiles through the upper Permian and the lowermost Triassic were measured and sampled at the north side of Marmierfjellet (Fig. 2). Detailed investigations of the sediments were carried out in well-exposed cliff and stream sections. Samples were collected for ichnofacies and geochemical analysis and for petrographic investigations. Fossiliferous samples were also systematically collected for later identification and descriptions of both trace fossils and skeletal material. Some of the illustrated specimens are housed in the Institute of Geological Sciences of the Jagiellonian University, Poland (collection prefix INGUJ207P). Other material is housed at Tromsø University Museum, University of Tromsø, Norway (collection prefix TSGF). The illustrated specimens seen in the field but not collected have not been allocated numbers. Six samples of fine-grained sediment were selected for palynology: two samples from a shaly interval in the Kapp Starostin Formation (198.80 and 218.00 m) and four closely spaced samples from the upper succession (361.20 – 374.70 m) across the presumed Permian–Triassic transition as well as the boundary between Kapp Starostin and Vikinghøgda Formations (361.75 m).

Trace element analysis

Whole-rock trace element analysis of shales was performed by Acme Analytical Laboratories Ltd., Vancouver, Canada. The method applied was a four-acid digestion (heated in HNO_3 – $HClO_4$ –HF to fuming and taken to dryness, and the residue then dissolved in HCl) dissolving a 0.25 g split of powdered sample material. Subsequently, the solutions were analysed for 41 different elements with an inductively coupled plasma mass spectrometer. In this study, we

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have used the Ni and V analysis from shales, totalling 96 samples. The detection limits for Ni and V are 0.1 and 1 ppm, respectively.

Fine-grained, laminated marine sediments are typically enriched in the trace elements Ni and V. This type of sediment, deposited under oxygen-depleted bottom-water conditions, enhances the incorporation of redox-sensitive elements. In such bottom-water conditions, V is reduced from V(V) in vanadate anions to reactive species of lower valence, V(IV). The presence of dissolved hydrogen sulphide causes further reduction to V(III). V is overall enriched in the sediment by the adsorption and formation of organic complexes. The enrichment of Ni, though with unchanged valence, is due to the formation of insoluble sulphides in the presence of dissolved hydrogen sulphide (Wehrli & Stumm 1989; Breit & Wanty 1991; Emerson & Huested 1991; Wanty & Goldhaber 1992; Calvert & Pedersen 1993).

Trace element ratios, such as the whole-rock V/(V+Ni) ratio in shale, are valuable for describing the bottom water conditions during deposition of fine-grained marine sediments (Hatch & Leventhal 1992; Arthur & Sageman 1994; Wignall 1994; Hoffman et al. 1998; Rimmer et al. 2004; Hansen et al. 2009; Zhang et al. 2011). For distinguishing differences in anoxicity of the bottom waters, we have used here the boundary values from Hatch & Leventhal (1992). A V/(V+Ni) ratio less than 0.46 indicates oxic conditions. Ratios between 0.46 and 0.60 and between 0.54 and 0.82 indicate dysoxic conditions, anoxic bottom-water conditions, respectively. In this paper, the intermediate value 0.57 is applied for discrimination between dysoxic and anoxic bottom-water conditions. A V/(V+Ni) ratio higher than 0.84 indicates sulphidic bottom water in a strongly stratified water column. Although we have utilized this trace element ratio to determine the anoxicity of the bottom water, care is taken in the interpretation by comparing the V/(V+Ni) ratio with other data presented in this study, because the V/(V+Ni) ratio has been limited to marine shale. This implies that V/(V+Ni) ratios need to be treated together with trace fossil associations and other evidence that may describe the depositional conditions in an adequately independent way.

Palynology

The samples were prepared for analyses with standard palynological procedures. The finegrained sediment samples were dried, weighed and crushed before treatment with HCl, HF, HNO₃ and KOH to remove carbonates and silicates and to oxidize the remaining organic material. Minute organic material was removed with 11 μ mesh size filters and the resulting residue was mounted in glycerine jelly on glass slides for microscope studies

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