Petrographic descriptions for sandstone samples for which detrital zircon U-Pb geochronological data are provided in Tables S3-S13.

Twelve samples from the Victoria Group reported here come from the Shackleton Glacier and Queen Alexandra Range regions, and one sample from the Ohio Range. These are listed in approximate stratigraphic order (see also Fig. 4a). Geographic locations are shown in Fig. 3, and full analytical data for new detrital zircon U-Pb analyses are presented in Supplementary Tables S3-S13.

07-2-4. Fairchild Formation, Mt. Rosenwald. One hundred and thirty six meters above the base of the formation. Fine-grained sandstone, with minor plagioclase (sodic andesine) and lesser K-feldspar (orthoclase and microcline). Accessory micas (muscovite and lesser biotite). Heavy minerals include zircon and garnet, lesser opaques, and rare tourmaline. Carbonaceous shreds are scattered. Matrix of phyllosilicate shreds and some secondary silica..

07-2-12. Lower Buckley Formation, Mt. Rosenwald. Sixty four meters above the base of the formation. Medium-grained quartzo-feldspathic sandstone. Much of the quartz is strongly corroded; quartz includes polycrystalline grains. Minor plagioclase (oligoclase-andesine) and traces of K-feldspar. Micas include muscovite and lesser biotite. Heavy minerals are mainly garnet and zircon, with a trace of apatite and tourmaline. Fine-grained white mica forms the abundant matrix; replaces detrital quartz grains and such replacement is probably widespread and accounts for the abundance of matrix phyllosilicate.

MBB 73-3. Pagoda Formation, Mt. Butters. Seventy three meters above the base of the formation. Medium-grained well-sorted quartz-rich sandstone. Grain margins of quartz are commonly sutured. Plagioclase (oligoclase-andesine) and lesser K-feldspar are minor. Accessory muscovite and biotite. Heavy minerals include garnet, epidote, opaques and zircon. Matrix includes patchily distributed secondary fine-grained brown phyllosilicate, and fine-grained recrystallized quartz.

11-4-3. Lower Buckley Formation, south spur of Clarkson Peak. One hundred and twenty two meters above the base of the formation and two meters above the upper contact of a major sill. Medium-grained quartz-rich sandstone, moderately well sorted, angualr to sub-round grains. Sparse highly altered feldspar. Heavy minerals include garnet and zircon. Abundant siliceous matrix along with colorless and pale brown phyllosilicate flakes; largely resulting from the replacement of detrital feldspar; minor silica overgrowths on quartz grains. Scattered carbonaceous matter.

11-5-22. Upper Buckley Formation, Mt. Bowers. Thirty three meters above the lower Buckley/upper Buckley contact and 425 m above the base of the Buckley Formation. Described in Elliot et al. (2015).

11-4-10. Upper Buckley Formation, south spur of Clarkson Peak. Three hundred and eighty four meters in section (the second sandstone in the upper white cliff). Fine-grained volcanic sandstone, moderately sorted, sub-angular to sub-round. Quartz with lesser feldspar (andesine) which is highly altered and partially replaced by zeolite. Muscovite and biotite are accessory. Heavy minerals include zircon, garnet and sphene. Abundant volcanic rock fragments: grains are flow banded, microcrystalline and siliceous, fine to very fine-grained and feldspathic with or without flow texture, and microporphyritic. Sparse quartz-mica schist rock fragments. The matrix includes siliceous matter and phyllosilicate flakes and shreds. Carbonaceous matter is common.

H3-384b. Mt. Glossopteris Formation, Terrace Ridge, Mt. Schopf, Ohio Range. Three hundred and ninety meters above the base of the section (Long, 1964, 1965). A medium-grained volcanic sandstone. Quartz and strongly altered plagioclase (andesine) are subordinate to abundant volcanic rock fragments. Heavy minerals include zircon and apatite. Volcanic grains include aggregates of felspar laths with trachytic textures, quartzo-feldspathic microcrystalline grains, and occasional microporphyritic (quartz and feldspar) grains. Scattered carbonaceous material. The matrix includes phyllosilicate but is largely irresolvable.

96-35-2. Upper Buckley Formation, Layman Peak. Seventy meters below the top of the formation. A medium-grained volcaniclastic sandstone with little quartz but much strongly altered plagioclase (oligoclase-andesine) and abundant altered intermediate to silicic volcanic particles. The latter include grains with trachytic and non-trachytic textures, and with sparse microphenocrysts; pumice fragments are present. Replacement of volcanic particles by very fine-grained quartz is common. Carbonaceous debris is common.

96-36-1. Upper Buckley Formation, Collinson Ridge. One meter below the contact with the Fremouw Formation. This medium to fine-grained sandstone carries scattered quartz grains, rare highly altered plagioclase, and few recognizable volcanic rock fragments. Accessory zircon. Most of the sandstone consists of aggregates of fine- to very fine-grained quartz, aggregates of an orange-brown secondary mineral, brown phyllosilicate clumps, and sparse secondary white mica.

07-6-2. Fremouw Formation middle member, Halfmoon Bluff. Forty six meters above the base of the member (which is 170 m thick where measured). Medium-grained quartzo-feldspathic sandstone with common volcanic rock fragments. Feldspars include plagioclase (sodic andesine) and rare K-feldspar, and accessory minerals are biotite and rare zircon, garnet and apatite. Volcanic fragments include plagioclase aggregates with trachytic and non-trachytic textures, very fine-grained quartzo-feldspathic grains, and fine quartz aggregates. Rare granophyric grains. The matrix consists of zeolite, which has also replaced some plagioclase, and extremely fine-grained phyllosilicate.

07-6-3. Fremouw Formation upper member, Halfmoon Bluff. Seventy five meters above the base of the member. Medium to coarse-grained quartzo-feldspathic sandstone with abundant volcanic rock fragments. Plagioclase (andesine) exceeds K-feldspar; biotite is a common accessory mineral together with lesser muscovite; very sparse zircon and sphene. Volcanic grains include trachytic and non-trachytic feldspathic grains, cherty (silicified) grains and microcrystalline quartzo-feldspathic grains with or without microphenocrysts of quartz and feldspar. The matrix is formed of very fine-grained phyllosilicate.

90-2-52. Falla Formation, Mt. Falla. From 252 m in the type section of the Falla Formation. Medium-grained quartzo-feldspathic sandstone; quartz includes some polycrystalline grains; feldspars include both plagioclase (andesine) and lesser K-feldspar (microcline and orthoclase); biotite, commonly altered, and lesser muscovite are common and many are bent or squashed; heavy minerals include zircon plus rare garnet and sphene. Volcanic rock fragments are dominated by grains with trachytic textures or are very fine-grained and siliceous. Carbonate and phyllosilicate form the cement.