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Was the Stonehenge Altar Stone from Orkney?

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5516. Lower Stromness Flagstone Formation

Netherton Road, Mainland Orkney

The rock is a laminated, well-sorted, dolomitic, micaceous, arkosic, fine-grained sandstone. Overall, the rock is greyish orange pink (5YR 7/2 on the Geological Society of America Rock-color chart). It is uniform and grain supported. Thin section examination shows it comprises sub-rounded to subhedral, monocrystalline quartz grains showing uniform extinction, plus lesser amounts of lath-shaped muscovite, untwinned feldspar, plagioclase, dolomite and minor amounts of microcline, together with trace amounts of rounded to euhedral apatite, small, zoned and euhedral zircon, green to brown tourmaline, and rare, orange rutile. Grains are present in thin, 50 – 300 µm wide, heavy mineral bands which carry titania, apatite, zircon, tourmaline and possible garnet. Rock clasts are very rare and most are internally very fine-grained, comprising 'chert' or clay minerals. A single, 150 µm diameter, igneous rock clast has fine-grained titania replacing iron titanium oxides.

Quartz, showing uniform extinction, is the most abundant mineral; there is little evidence for authigenic quartz overgrowths and adjacent grains have straight edge contacts with no sign of embayments. Feldspars are widespread and many are unaltered and show authigenic overgrowths. Polysynthetically twinned plagioclase has pale brown, cloudy cores within clear, often euhedral, margins. Untwinned feldspar and microcline also have cloudy cores within clear, untwinned euhedral terminations. Untwinned feldspar is more abundant than plagioclase, while feldspar alteration to fine-grained white mica/clay is rare.

Muscovite is common and comprises short stubby crystals and rarer, long thin laths. Most muscovite is aligned along laminae. Rarely it is cloudy or shows show feint splaying at its ends or is bent around quartz/feldspar grains. Possible bleached biotite is very rare, and chlorite was not detected.

Carbonate is abundant. Euhedral, twinned, zoned dolomite rhombs, 30–50 but up to 100 µm size, are present locally within the more abundant, anhedral, brown carbonate. Rare, zoned dolomite has limonite-stained cloudy cores within clear margins. Oxidation to limonite is very rare.

Zircon is both unzoned (25 – 50 µm in diameter) to highly zoned (30 µm in diameter) and is up to 100µm in length. Rounded apatite, 50 – 80 µm in diameter, is present, and laths are up to 120 µm in length. Rare apatite carries very fine-grained, 1 µm diameter, sulphides. Tourmaline is rounded to euhedral and 50 – 100 µm in diameter, whilst very rare graphite forms 70 x 15 µm size laths.

Chromite forms 25 – 50 but up to 80 µm diameter, euhedral to fractured grains. Single, lath-shaped to rounded, rarely twinned, detrital rutile crystals are 40 – 70 but up to 100 µm in length and have dark red/orange internal reflections. Thin, authigenic, euhedral rutile crystals are widespread, many 5 x 2 to 10 x 2 µm in size. Primary magnetite is totally absent, as is hematite. Primary ilmenite is altered to titania.

Original iron titanium oxides, including ex-ilmenite crystals, are 25 – 70 but up to 150 µm in length and are widespread. Many now comprise fine-grained, poorly crystalline titania with pale internal reflections; in others the titania comprises fine-grained, euhedral crystals. Euhedral crystalline titania, 25 – 50 µm in size with pale internal reflections, forms discrete monocrystalline crystals. Elsewhere, 100 µm diameter patches of fine-grained, 5 – 10 µm,

crystals occur. Small rutile laths are locally collected into 'nests'. Rare, 25 – 50 µm diameter 'leucoxene' is present.

Sulphides occur in very minor amounts and are dominated by pyrite/marcasite. Pyrite is present as rare, 10 – 25 µm diameter, framboidal patches. Discrete euhedral pyrite is 1 – 5 but rarely up to 25 µm in diameter and is oxidised to limonite. Euhedral rhombic marcasite is more abundant and displays a characteristic habit. Thin, 1-2 µm wide, but 70 – 120 up to 200 µm long, limonite has 2 – 10 µm diameter marcasite rhombs growing out from it; some pyrite and possible pyrrhotite is intergrown with marcasite. Chalcopyrite is rare but relict chalcopyrite is present in 25 – 100 µm, dark, zoned limonite or is intergrown with pale coloured, 25 µm diameter, sphalerite in a 150 µm diameter aggregate.

5510. Upper Stromness Flagstone Formation

Birsay, Mainland Orkney

The rock is a dark yellowish orange (10YR 6/6 on the Geological Society of America Rock-color chart). It is a laminated, well-sorted, dolomitic, micaceous, arkosic, fine-grained sandstone with thin carbonate-mica rich laminae. The fine-grained sandstone is uniform, and grain supported, comprising quartz grains and lesser amounts of short, lath-shaped muscovite, untwinned feldspar, plagioclase, dolomite, minor amounts of microcline and trace amounts of apatite, zircon, green to brown tourmaline, rutile and garnet. Rock clasts are very rare and are internally very fine-grained, comprising 'chert' or clay minerals. Quartz and feldspars show some elongation aligned along the laminae, as do the majority of the muscovite laths. Thin carbonate-muscovite-rich laminae mantle coarser grained, but still fine-grained, sandstone.

Monocrystalline, sub-angular to sub-rounded quartz grains showing uniform extinction are dominant; there is little evidence for authigenic quartz overgrowths and adjacent grains have straight edge contacts with little sign of embayments. Locally, quartz forms mosaic patches or is a cement. Feldspar laths are widespread, and their alteration is slight, so many are unaltered and show authigenic, euhedral terminations. They comprise polysynthetically twinned and zoned plagioclase and untwinned feldspar and microcline; untwinned feldspar is more abundant than plagioclase and is euhedral against fine-grained carbonate. Thin, brown biotite laths are very rare, and chlorite was not recognised.

Muscovite is common and comprises short, stubby, 15 – 25 µm wide laths and rarer, long, thinner laths. There is little evidence of kinking around quartz/feldspar grains or splaying. Muscovite laths, some long, enclosed within carbonate mantles, occur within carbonate-rich laminae and in carbonate sheaths about slightly coarser grained sandstone areas.

Carbonate is abundant. Zoned dolomite as 10 – 40 µm size rhombs are present; some occur within quartz mosaics but most lie within the more abundant brown, anhedral carbonate. All carbonates show yellow, fine-grained limonitic staining. Thin carbonate-muscovite rich laminae (with minor quartz) enclose coarser grained sandstone and siltstone. Very locally these carbonate laminae carry clear sparry calcite cores. Commonly, single muscovite laths are enclosed within a carbonate sheath. Other laminae are quartz-mica rich but carbonate-poor or are quartz-dolomite-rich but mica-poor.

Heavy minerals bands are poorly developed and are dominated by titania grains and zircon. Zircon, 10 – 50 µm in diameter, is unzoned to highly zoned and some grains are euhedral

but others are fractured. Rounded apatite, 30 – 50 µm in diameter, is present and rarely carries very fine-grained sulphides, including possible 10 µm diameter pyrrhotite.

Chromite forms 15 – 50 but up to 75 µm diameter euhedral to angular grains. Some chromite is zoned, with very thin external pale-coloured rims. Single, lath-shaped to rounded, rarely twinned, detrital rutile crystals are 20 – 50 µm in size with dark red/orange internal reflections. Very rare rutile laths are up to 100 µm long.

The most abundant heavy minerals are former iron titanium oxides, including former ilmenite, but all are now totally altered to 25 – 70 but up to 100 µm diameter rounded, fine-grained, poorly polished titania showing pale-coloured white or yellow internal reflections. In some of these grains the titania has recrystallised. Small, 25 – 50 µm diameter, leucoxene intergrowths are rare.

Very locally, titania is present as a cement to quartz grains, but much occurs as 15 – 75 µm diameter, discrete single crystals with pale yellow and rarely blue internal reflections. Elsewhere, titania crystals show swallow tail twinning. Rutile occurs as very small crystals, 5 – 10 µm in length, in aggregates; this is an unusual habit and probably characteristic of the rock.

Pyrite is rare, forming 2 – 10 µm diameter, unaltered crystals within detrital grains. Larger pentagonal dodecahedral pyrite crystals, 20 – 25 µm in size, are altered to limonite. Zoned/banded limonite, 10 -50 but up to 100 µm in diameter, has replaced sulphides, especially pyrite.

5505. Lower Stromness Flagstone Formation

Yesnaby, Mainland Orkney

A laminated, well-sorted, dolomitic, micaceous, arkosic fine-grained sandstone. It is moderate yellowish-brown (10YR 5/4 on the Geological Society of America Rock-color chart). It is uniform, (especially within each lamination/bedding unit) and grain supported, comprising sub-rounded to subhedral monocrystalline quartz grains showing uniform extinction plus muscovite laths, untwinned feldspar, plagioclase, dolomite, minor amounts of microcline, and trace amounts of rounded apatite, zircon, tourmaline and rutile. Rock clasts are very rare and are internally very fine-grained, mainly comprising 'chert'. Quartz and feldspars show some elongation aligned along the laminae. Muscovite forms short stubby crystals and rarer long thin laths and whilst the majority of the laths lie along the laminae some are at high angles to it. Heavy minerals bands are poorly developed, are up to 150µm in width and mainly carry 25 µm diameter, detrital, altered iron titanium oxides, now all titania, plus up to 50 µm diameter unzoned zircon. Much of the titania is present as authigenic, pale-coloured, euhedral crystals. Very locally baryte forms a cement about quartz grains and may be associated with small fractures.

Sub-angular to sub-rounded quartz grains showing uniform extinction dominate; there is slight evidence for authigenic quartz overgrowths and adjacent grains mainly have straight edge contacts but locally there are signs of embayments. Some quartz grains are aligned along the main fabric. Feldspars are widespread and many are unaltered, with some showing euhedral terminations. Polysynthetically twinned plagioclase, with rare zoning, has pale brown, cloudy cores and carbonate dust within clear, often euhedral margins. Untwinned feldspar and microcline also have cloudy cores within clear untwinned euhedral terminations. Untwinned feldspar is more abundant than plagioclase and microcline is often larger than most grains. Feldspar alteration to fine-grained white mica/clay is rare. Chlorite was not recognised.

Carbonate is abundant. Euhedral, unzoned dolomite rhombs are present, some within the more abundant anhedral, brown carbonate. Most carbonate does not look like cement, although very locally coarse-grained dolomite-rich areas occur. Some carbonate may be ex-fossils and or appears tubular. The sandstone shows limonite-stained carbonate.

Baryte, with abundant fluid inclusions and sweeping extinction, forms a minor and very local cement about detrital quartz grains; some is adjacent to carbonate or white mica.

Opaque and semi-opaque minerals are dominated by authigenic titania. Zircon is 10 – 50 μm in diameter, rounded apatite is 10 μm in diameter, green, zoned, euhedral tourmaline and very rare graphite 25 – 50 μm in size are present. Rare chromite is 25 μm in diameter. Single, lath-shaped to rounded detrital rutile crystals are 20 – 50 μm in size and have dark red/orange internal reflections. Primary magnetite is totally absent as essentially is hematite.

Original iron titanium oxides are 25 – 50 μm in length and are rare; many were probably primary ilmenite. They now comprise fine-grained, poorly crystalline titania with pale internal reflections. Euhedral, crystalline titania 5 – 50 but up to 75 μm in size with pale internal reflections, forms discrete, monocrystalline crystals and is widespread. Elsewhere, 100 μm diameter patches of fine-grained 5 – 10 μm size crystals are present. Rare, 30 – 50 μm diameter, fine 'leucoxene' is present. Hematite pigment is very rare as 20 μm diameter patches of 1 μm long laths (pigment).

Sulphides are present in minor amounts and are dominated by pyrite; some is quite yellow. It is present as 5 – 60 x 30 μm size crystals and laths and within small aggregates. Most pyrite is slightly altered to thin, 2 -5 μm wide limonite rims but some is extensively oxidised.