Suckling Dome and the Australian–Woodlark plate boundary in eastern Papua: the geology of the Keveri and Ada’u Valleys

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The Owen Stanley Fault Zone (OSFZ) is the low-angle thrust boundary between the Australian and Woodlark plates. The eastern extension of the OSFZ links with the Woodlark Basin spreading centre. Recent tectonic models of eastern Papua depict the OSFZ boundary passing through the Mt Suckling district, with the Keveri Fault a key component. Gravity data clearly show that the OSFZ and the Papuan Ultramafic Belt (PUB) pass north of Mt Suckling. Tectonised mafic and ultramafic rocks of the Mt Suckling district, previously referred to the PUB, are reassigned to the Awariobo Range Complex (new name). Extensive pillow basalts previously referred to the middle Eocene part of the Kutu Volcanics at the top of the PUB sequence are, in the map area, reassigned on lithological and biostratigraphic grounds to the late Oligocene–middle Miocene Wavera Volcanics. The detailed work reported here indicates that the Keveri Fault is unrelated to the OSFZ with no evidence for thrusting along the structure. The area’s tectonic history has been dominated by large vertical displacements along the Keveri Fault. The commencement of late Miocene buoyant uplift of the Suckling Dome (new name), related to granite intrusion into thick crust of the eastern Papua region, marks the inception of the Keveri Fault and coincides with the initiation of Woodlark rifting. The fault facilitated much of the rapid vertical movement of the dome, with an estimated 8000 m of uplift (2.5 m/10³ a) since the late Miocene. Movement on the Keveri Fault is notably different from structures flanking other metamorphic core complexes in eastern Papua. There is no field evidence for the development of a low-angle, south-dipping detachment fault along the southern margin of the Suckling Dome. The Suckling Dome is the westernmost of the eastern Papua domes, localised within a broad extensional zone that continues to propagate westward along the OSFZ plate boundary.

KEY WORDS: Australian plate, Keveri Fault, Owen Stanley Fault Zone, Papuan Orogen, Papuan Ultramafic Belt, tectonics, Woodlark plate.

INTRODUCTION

The Owen Stanley Fault Zone (OSFZ) is an important tectonic element of the Papuan Orogen. It is the active plate boundary separating continental rocks of the Australian plate from ultramafic and mafic rocks of the Papuan Ultramafic Belt (PUB) on the Woodlark plate. The eastern extension of the OSFZ is thought to link with the Woodlark Basin spreading centre (Figure 1; Daczko et al. 2011; Little et al. 2011; Davies 2012; Fitz & Mann 2013). For much of its length on the Papuan Peninsula, the OSFZ consists of two or more faults. At the western and eastern ends of the fault zone, individual structures merge, but elsewhere they are separated by a fault slice some 5–10 km wide (Davies 1971; Daczko et al. 2011; Little et al. 2011; Fitz & Mann 2013). Individual shear zones may be between 100 and 500 m wide (Davies 1971). Long, straight and deeply incised valleys along the trace of the OSFZ, including the Waria River Valley, suggest a structure that is steep to vertical. Davies (1971) concluded that the OSFZ is a thrust, despite observation of only one low-angle dip (at locality 920’S), with younger vertical strike-slip normal faulting now coinciding with the thrust plane.

Recent regional geological maps of eastern Papua (Webb et al. 2008; Daczko et al. 2011; Little et al. 2011; Fitz & Mann 2013) depict a large “embayment” structure in the OSFZ in the Mt Suckling district in the interval 148°E to 149°E (EB on Figure 3). The origins of this configuration can be traced to fault patterns interpreted during Bureau of Mineral Resources (BMR) reconnaissance 1:250 000 mapping (Davies & Smith 1974). Subsequent authors have accepted the faults mapped in the Mt Suckling district as that expected for a low-angle, north-dipping thrust. The Keveri Fault is a significant component of the “embayment” structure and new field and geophysical evidence indicates it to be a high-angle normal fault to depths in excess of 7–10 km and not a low-angle thrust.

This paper presents my field observations between 1988 and 2014, and geophysical interpretation on the
geology and structure in the Keveri and Ada’u Valleys in the Mt Suckling district (Figures 2, 4a). The district is remote and difficult to access, and there have been no detailed published studies since the BMR reconnaissance mapping of 1965/1968 (Appendix). A well-developed sedimentary record in the map area is unlike anything else along the OSFZ and has been important in elucidating tectonic events.

TECTONIC SETTING OF EASTERN PAPUA

Papuan Orogen

Rocks of the Papuan Orogen (Little et al. 2011) crop out in a 750 km belt underlying the Papuan Peninsula and islands of the Milne Bay district, including the D’Entrecasteaux Islands (Goodenough, Fergusson, Normanby), Woodlark Island and the Louisiade Archipelago (Misima, Deboyne, Rossel, Sudest, Engineer Group, Conflict Group). The orogen’s geology documents a history of convergence and extension between the Australian plate and microplates including the Woodlark and Solomon plates during arc–continent collision (Davies & Smith 1971; Smith & Milsom 1984; Hall 2002; Webb et al. 2008; Whattam et al. 2008; Whattam 2009; Daczko et al. 2011; Little et al. 2011; Baldwin et al. 2012; Fitz & Mann 2013). Elevations in excess of 2000 m are present on Goodenough and Fergusson islands and on the Papuan Peninsula (Mt Suckling—3676 m—is the highest mountain in Papua, and for comparison, is only 48 m below Aoraki/Mt Cook, South Island, New Zealand). Volcanism, commonly widespread, has occurred in four discrete episodes in the Papuan Orogen, viz: during the middle Eocene, late Oligocene–middle Miocene, middle–late Miocene to Pliocene and Quaternary. The Quaternary volcanism is related to extension and sea-floor spreading in the Woodlark Basin. Present WSW convergence across the OSFZ has been estimated using GPS observations at ~20 mm/a perpendicular to the fault zone north of 8° S (Wallace et al. 2004; Daczko et al. 2011).
Pre-middle Miocene geological evolution

BASEMENT—OWEN STANLEY METAMORPHIC COMPLEX

Basement rocks throughout the Papuan Orogen consist of Early Cretaceous (120–107 Ma; Kopi et al. 2000) metasediments and metavolcanics of the Owen Stanley Metamorphic Complex (Davies 2012). A 375 km belt of greenschist pelitic and psammitic metasediments with subordinate metavolcanics (Owen Stanley Metamorphics, Kagi Metamorphics) and unmetamorphosed sediments (Kemp Welch Formation) runs the spine of the Papuan Peninsula. Thickness estimates for the unit
range up to 30 km (Smith & Davies 1973a). Equivalents of the Owen Stanley Metamorphics on the islands include the Prevost Metamorphics (Normanby Island; Smith & Davies 1973a), Calavados Schist (Deboyne, Sudest, Rossel islands) and Umuna Schist (Misima Island; Lewis & Wilson 1990). Low-grade metavolcanics, in places pillowd submarine basalt lava with interbedded pelagic limestone and rare terrigenous sediment (Goropu Metavolcanic), crop out over a 1600 km² area in the Mt Suckling and Mt Dayman districts and eastwards to 149°43'E (Figure 2; Smith & Davies 1976). This unit has an estimated 3000–4000 m thickness (Smith & Davies 1976). Offshore equivalents include the Kurada Metavolcanics (Normanby Island).

Emplacement of late Mesozoic mafic and ultramafic rocks (PUB) indicates commencement of arccontinent collision in the Papuan Orogen and the formation of the Australian plate—Woodlark plate boundary (OSFZ). The PUB complex crops out over a length of 375 km. The ophiolite consists of a sequence of ultramafic (4–8 km thick), gabbroic (4 km thick) and basaltic rocks (4 km thick). A sheeted dyke complex is only rarely observed in the sequence (Davies 1971). There is no direct radiometric evidence for the age of the PUB with the age of

Figure 3 Regional gravity map of eastern Papua (modified after GSPNG & BGS 2004). The Papuan Ultramafic Belt (PUB) is reflected by a series of strong, elongate and coherent gravity anomalies. The Owen Stanley Fault Zone (OSFZ) is shown as a red line (from Fitz & Mann 2013). The dashed black line represents the OSFZ as interpreted from gravity data (this paper). The coastline is shown as a fine white line. Gravity data indicate the PUB and the bounding OSFZ passes south of Mt Trafalgar (MT) and Mt Victory (MV) volcanoes and Cape Nelson and then along the southern margin of Collingwood Bay (CB) towards Cape Vogel Peninsula. The "embayment" structure (EB) in the OSFZ between 148°E and 149°E does not reconcile with geology (the subject of this paper); the inferred low-angle structure in this region is the Keveri Fault (KF), which is shown by inversion studies of detailed low-level airborne total magnetic intensity data to be vertical to at least 7–10 km depth. Much of the geology of the Mt Suckling district and the area immediately to the west, previously mapped as part of the PUB, is indicated by both geology and geophysics to be unrelated to the ophiolite complex. Other tectonic features include Normanby Island (NI) where the OSFZ is thought to link with the Woodlark Basin spreading centre (Daczko et al. 2011; Fitz & Mann 2013), and the D'Entre- casteaux Islands (DEI), Mt Suckling (MS) and Mt Dayman (MD), dome complexes. Coverage of the Keveri and Ada’u Valleys 1:50 000 geological map sheet (Figure 4a) is shown.

PALEOCENE COLLISION—FORMATION OF THE OWEN STANLEY FAULT ZONE AND EMLACEMENT OF THE PAPUAN ULTRAMAFIC BELT

The PUB complex crops out over a length of 375 km. The ophiolite consists of a sequence of ultramafic (4–8 km thick), gabbroic (4 km thick) and basaltic rocks (4 km thick). A sheeted dyke complex is only rarely observed in the sequence (Davies 1971). There is no direct radiometric evidence for the age of the PUB with the age of...
the ophiolite constrained to ca 71–65 Ma (Late Cretaceous) by foraminiferal dating of fine sediments associated with basalt and Paleocene tonalite stocks and plutons that intrude the gabbroic part of the complex (Davies 2012). Dating of metamorphic sole to the ophiolite suggests emplacement and plate boundary formation commenced by 58 Ma (late Paleocene; Lus et al. 2004).

GEOPHYSICAL SIGNATURE OF THE PAPUAN ULTRAMAFIC BELT

The PUB is associated with strong, elongate and coherent gravity and magnetic anomalies (Figure 3; Davies 1980; GSPNG & BGS 2004). By contrast, there is no gravity anomaly associated with the ultramafic rocks of the Mt Suckling district (Figure 2), suggesting they are unrelated to the PUB. East of 148°30′E, the gravity data are clear in indicating that the PUB and the bounding OSFZ passes south of Mt Trafalgar and Mt Victory volcanoes and Cape Nelson, before passing offshore into Collingwood Bay (Figure 3). Extension of the OSFZ east of Collingwood Bay into the Goodenough Basin is uncertain and may be via a jog structure(s) north of and around Cape Vogel Peninsula to connect with the Goodenough Fault, one of the most active faults of the Woodlark rift (Figure 3; Little et al. 2011). Gravity data also indicate that the easternmost limit of the PUB, as a coherent intact body, is 149°30′E (Figure 3). Fitz & Mann (2013) interpreted the presence of Paleocene gabbro and diabase recovered by ODP Leg 180 drilling on Moresby Seamount, NE of Normanby Island, as evidence for the eastern extension of the PUB (Figures 1, 3).

MIDDLE EOCENE EXTENSION—KUTU VOLCANICS

Middle Eocene pillowd basalt lava, with interbedded sparsely fossiliferous, fetid, flaggy deep-water limestone (Kutu Volcanics), widespread on the Papuan Peninsula and some islands, was erupted from numerous volcanic centres and marked the cessation of convergence and the commencement of a period of crustal extension. Numerous narrow (2–3 m) vertical gabbro dykes typically intrude basalt and limestone units (e.g. Pini Range quarry exposures, 150°16′E/10°22′S; Lindley 1991). These gabbro dykes are mineralogically similar to gabbros of the middle Eocene? East Cape Gabbro (150°45′E/10°15′S; Smith & Davies 1973a) and the late Eocene—middle Oligocene Sadowa Intrusive Complex (Yates & de Ferranti 1967), suggesting the intrusive bodies may be subvolcanic plutons. The Sadowa gabbro is a large elongated (120 km × 30 km) pluton extending from 147°15′E to 148°15′E and consists of olivine gabbro, pyroxene–hornblende diorite, granophyre and ultramafic rocks (Yates & de Ferranti 1967; Pieters 1978; Rogerson et al. 1981). The pluton was emplaced near the margin of the Australian plate and is subparallel to the OSFZ. Both northern and southern contacts of the pluton are either fault controlled or parallel the regional strike of sedimentary units (Yates & de Ferranti 1967). The proposed genetic link between the East Cape Gabbro and Sadowa Intrusive Complex plutons, and the Kutu Volcanics suggests crustal extension and the formation of a magmatic arc in the middle Eocene. Middle Eocene extension is counter to the view of other authors who proposed plate convergence and collision continued into the early Miocene (summarised in Little et al. 2011, p. 43).

LATE OLIGOCENE—MIDDLE MIOCENE TECTONIC STABILITY

Volcanic and tectonic quiescence prevailed throughout most the Papuan Orogen during the late Oligocene—middle Miocene. Limestone, marl, tuffaceous sandstone and siltstone units with minor limestone (Ada’u Limestone, Woruka Siltstone, Castle Hill Limestone; Davies & Smith 1974; Modewa River Beds; Smith & Davies 1973a) were deposited in shallow seas across the Papuan Peninsula. Several submarine eruptive centres contributed pillow basalt lavas on Cape Vogel Peninsula (CVP, Figure 1; Dabi Volcanics; Davies & Smith 1974) and in the Mt Suckling district (Figure 2; Wavera Volcanics, this paper). Localised occurrences of andesitic lava, agglomerate, volcanolithic conglomerate and arenite, with dense grey limestone, crop out on Normanby Island (151°00′E/10°00′S; Sewa Beds; Smith & Davies 1973a). The problematic Astrolabe Agglomerate (no younger than 5.7 Ma; Pain 1983) is a coarsely stratified, clast-supported deposit of angular and subrounded basalt with intercalated thin lenses of lithic tuff containing current and graded bedding. The formation crops out on the Sogeri Plateau and the Astrolabe Range, north of Port Moresby. Casts of tree trunks have been found in both fine and coarse units, and the deposit has no identified volcanic source (Ollier 1969; Pieters 1978; Pain 1983).

Late Cenozoic geological evolution

RIFTING AND THE FORMATION OF THE WOODLARK SPREADING CENTRE

Woodlark Basin rifting probably commenced in the late Miocene (Taylor et al. 1999) and continues to the present, splitting the continental crust of eastern Papua (Little et al. 2011). As rifting has continued, the Woodlark spreading centre ridge has propagated westward >500 km into the rift (Little et al. 2011).

EXTENSIONAL TECTONICS

Three graben-like depressions are located at the eastern end of the Papuan Peninsula (Smith & Milsom 1984). Mullins Harbour is considered to be the oldest graben and is almost entirely filled by sediment (Smith & Milsom 1984). Milne Bay is an east–west-oriented graben varying in width from 12 to 14 km. It has subsided 775 m in the last 18 000 years with the accumulation of 450 m of sediment (Jongsma 1972). The youngest graben is the Goodenough Basin (GB, Figure 1). All three basins are thought to be the result of rift propagation associated with the Woodlark Basin rifting (Smith & Milsom 1984). The Goodenough Fault, bounding the southern edge of the Goodenough Basin, has estimated slip rates of 10–20 mm/a (Little et al. 2011). A Quaternary peralkaline rhyolite suite is presently being erupted from volcanic centres at the eastern end of Fergusson Island and on Dobu Island (Smith 1976). These peralkaline rocks are characteristic of a tensional environment (Smith 1976).
Figure 4
(a) Geological map of the Keveri and Ada’u Valleys, eastern Papua. (b) Geological cross-section from Badu Mountain to Mt Suckling showing the Suckling Dome. Refer to Figure 2 for section location and Figure 4a for formation names. Vertical exaggeration = 1:1. Figure 4 is available as a supplementary paper.
MAGMATIC AND VOLCANIC ACTIVITY

The post-middle Miocene evolution of the Papuan Orogen is characterised by two phases of magmatic-volcanic activity: (1) middle–late Miocene to Pliocene magmatism and volcanism; and (2) Quaternary volcanism related to extension and sea-floor spreading in the Woodlark Basin. These episodes are separated by a Plio-Pleistocene period of volcanic and tectonic quiescence (Smith & Milsom 1984). Middle–late Miocene to Pliocene volcanic rocks include the Cloudy Bay Volcanics (Smith & Davies 1973b), Five Bay Volcanics, Normanby Volcanics (Smith & Davies 1973a) and Amphiatt Volcanics (Davies 1973). Intrusions of middle–late Miocene to Pliocene age are widespread: Suckling Granite, Mai’iu Monzonite, Bonua Porphyry (Davies & Smith 1974; this paper); Ulo Ulo Gabbro, Watutti Gabbro, Gabahusuhusu Syenite, Magavara Syenite, Sigi Lege Gabbro (Smith & Davies 1973a); Luboda Granodiorite, Omara Granodiorite, Observation Island Granodiorite, Idgigodora Granodiorite (Davies 1973); and Boiou Microgranodiorite (Lewis & Wilson 1990). The volcanic activity is thought by many workers to have been associated with the development of the Trobriand Trough during the Miocene and magmatism generated by the southward subduction of the Solomon plate (Davies et al. 1987; Little et al. 2011). This is despite the Trobriand Trough being an aseismic structure (Davies et al. 1987).

STRATIGRAPHY

Cretaceous to early Eocene

Basement rocks in the Mt Suckling district include late Mesozoic to early Cenozoic mafic and ultramafic rocks and low-grade metamorphosed sedimentary and volcanic rocks (Figure 2). Tectonostratigraphic terranes follow those defined by Pigram & Davies (1987). The Bowutu terrane crops out north of the Keveri Fault and in the map area includes the Awariobo Range Complex (new name) and the Goropu Metabasalt. South of the fault, the Owen Stanley terrane includes the Owen Stanley Metamorphics. The middle Eocene part of the Kutu Volcanics, mapped by Davies & Smith (1974) and Smith & Davies (1976) across an extensive area south of the Keveri Fault is, in the map area, reassigned on lithological and biostratigraphic grounds to the Wavera Volcanics as originally proposed by Macnab (1967).

METAMORPHIC Core Complexes and Quaternary Volcanism

Metamorphic core complexes on the D’Entrecasteaux Islands (Goodenough, Mailolo, Oitabu, NW Normanby Domes) and the Papuan Peninsula (Dayman Dome) have heights in excess of 2000 m and are being exhumed at rates of ~20 mm/a (Ollier & Pain 1980, 1981; Hill et al. 1992; Hill & Baldwin 1993; Daczko et al. 2011; Little et al. 2011). The D’Entrecasteaux domes occupy a 30 km-wide belt of emergent continental crust in the central part of the otherwise submerged Woodlark rift (Little et al. 2011). They are inferred to have developed during the westward advance of sea-floor spreading in the Woodlark Basin and crustal extension along the OSFZ plate boundary (Davies 2012). The eastern Papuan region is one of only six regions in the world that document the transition from active continental rifting to active sea-floor rifting (Daczko et al. 2011). The Suckling Dome (this paper) is a newly recognised metamorphic core complex and is of particular interest as it is the westernmost of the actively rising eastern Papuan dome complexes.
an average content of 21 ppb Pt+Pd compared with the global average of 10 ppb Pt+Pd (Lindley et al. 2010a; W. D. Maier pers. comm. 2008). Pt+Pd is a significant component of Doriri Ni–PGM mineralisation with 1.0 m intervals of the lode containing up to 4.07 ppm Pd and 0.45 ppm Pt. Pd:Pt ratios for the lode typically exceed 7:1, with low Ir+Os+Ru concentrations. Panned concentrates from Dimidi Creek are anomalous for Pt+Pd with assays ranging up to 3310 ppb and 53 ppb, respectively.

Pt+Pd enrichment is associated with layered mafic deposits formed in intracontinental tectonic settings (e.g. the Bushveld or Great Dyke), with thick crust playing a key role in facilitating enrichment (W. D. Maier pers. comm.), and arc-type layered igneous complexes (Christie et al. 2006). Although there is an apparent association of PGM mineralisation with chromite, typical of the Bushveld and Great Dyke, the Awaribio Range Complex is interpreted to have formed in a magmatic arc setting.

Tectonite ultramafic rocks comprise more than 95% of the ultramafics mapped in the Awaribio Range Complex (Smith & Davies 1976). Cumulate ultramafic rocks were noted by Smith & Davies (1976) to be restricted to a small outcrop east of Dorri Creek in the upper Ada’u Valley. Common tectonite-ultramafic lithologies include harzburgite, peridotite and orthopyroxenite. Serpentinisation of these rocks is common with anastomosing and wispy bands of serpentinite imparting an obvious waxy appearance to rocks. Tectonite fabric and serpentinisation of ultramafic rocks may be related to tectonisation during the rapid uplift of the Suckling Dome. The presence of wehrlite is considered notable by Smith & Davies (1976) as this rock type is not known from the PUB.

A distinctive dunite comprising vitreous olivine crystals with disseminations of fine–coarse chromite is sourced only from two adjacent tributaries of upper Dimidi Creek (Bilia’e No. 1 and No. 2 streams), suggesting a localised dunite body or pipe-like feature with an estimated diameter of 1000–1500 m (Kd: Figures 4a, b). Dunite is associated with thick chromite seams, with chromitite float boulders and individual boulders of massive chromite up to 50 cm (attesting to the thickness of seams) present in Dimidi Creek. Individual chromite seams may show alteration selvages top and bottom of seams) present in Dimidi Creek. Individual chromite massive chromite up to 50 cm (attesting to the thickness chromitite float boulders and individual boulders of Dunite is associated with thick chromite seams, with Arumba (1993, plate 1a) described an apparently localised chromitite occurrence from the Sadowa Intrusive Complex at Mt Lawes, NE of Port Moresby that is visually similar to the Dimidi Creek chromitite. Specimens from both localities have lensoidal chromite seams (with distinctive pale alteration selvages) set in vitreous, coarsely crystalline dunite. Rhythmic layering of chromite seams, graded sedimentary settling, pinching of chromite seams and sedimentary scour-and-fill structures indicate that currents swept the floor of the dunite pipe, in what was a relatively stable crustal region.

Gabbroic rocks appear to be restricted to the Doriri Creek area. Reconnaissance mapping summarised in Smith & Davies (1976) suggested gabbro was present in a 1 km-wide strip along the southern edge of the Awaribio Range in the Ada’u Valley. Based on an assumed dip of 45° N, they calculated a thickness for the gabbro zone of 0.5 km. My mapping in the Ada’u Valley in consecutive streams (west to east) Dorri Creek, Oiso Creek, Urua Creek and Dimidi Creek does not indicate simple layered ultramafic/gabbro geology. At Doriri Creek, norite with orthopyroxenite and minor dunite is host to the Doriri Ni–PGM lode (González-Alvarez et al. 2013), whereas in nearby Oiso Creek and Urua Creek the lowermost 2–3 km intervals of each of these streams contain outcrops of pillow basalt of the Wavera Volcanics (Figure 4a). Peridotite with minor orthopyroxenite crops out along the entire length of Dimidi Creek.

There is no radiometric evidence for the age of the Awaribio Range Complex. Late Miocene–early Pliocene K–Ar ages for the Suckling Granite and Mai’iu Monzonite, which intrude the complex, help constrain the unit’s age to the Eocene based on similarities with the East Cape Gabbro and the Sadowa Intrusive Complex.

GOROPU METABASALT (Kg)

The Goropu Metabasalt (Smith & Davies 1976) is exposed in the upper Ada’u River in a fault slice between the Nonia Fault and the Keveri Fault. The formation may be intruded by ultramafic rocks of the Awaribio Range Complex east of the Nonia Fault in Ioleu Creek and Bonua River (east of the map area). Interpretation of detailed low-level total count radiometrics with field observations has been useful in distinguishing the Goropu Metabasalt from ultramafic rock of the Awaribio Range Complex and pillow basalt of the Wavera Volcanics. Metamorphosed basalts are typically massive, dense black rocks lacking any structure (e.g. pillows, columnar jointing). Metabasalt in Ioleu Creek is strongly jointed and locally intensely sheared, and includes fine-grained microdiorite. The Goropu Metabasalt is assigned a Late Cretaceous age using planktonic foraminifera from a calcareous schist member (Bonenua Schist Member) mapped by Smith & Davies (1976) to the NE and east of the map area near Mt Suckling and Mt Dayman, respectively.

OWEN STANLEY TERRANE

The Owen Stanley Metamorphics (Ko) typically consists of low-grade greenschist pelitic and psammitic metasediments and subordinate metavolcanics (Pigram & Davies 1987). Although the formation is not present in the map area, it crops out only 2 km to the west in Pigleg Creek, a tributary of the upper Domara River (Figure 2; Lindley & Tamu 1988). From here, the formation extends as a fault slice to the NW along the south bank of the Domara River (Figure 2; Davies & Smith 1974). Outcrop at Pigleg Creek consists of pelitic metasediments (phyllite and mica schist) and metavolcanics (amphibolite). Quartz veins crosscut the greenschist facies rocks and contain pyrite and chalcopyrite. The Owen Stanley Metamorphics is largely unfossiliferous, and the age of the formation is poorly constrained (Pigram & Davies 1987). The formation is assigned a Cretaceous age (Smith & Davies 1976).

Late Oligocene to Pliocene

Davies & Smith (1974) and Smith & Davies (1976) used limited reconnaissance traverses and aerial photograph interpretation to map an Eocene calcilutite and limestone unit (Godaguina Beds) restricted to the headwaters of the E’au River (= Godaguina River) and in
Urara Creek (Smith & Davies 1976, p. 25); the unit was interpreted as a lenticular body or bodies within the Kutu Volcanics (Smith & Davies 1976).

Float from the upper Ea’u River type area of the Godaguina Beds was inspected and on lithological grounds is referred to the late Oligocene–middle Miocene Wavera Volcanics. This is in accord with Macnab’s (1967) mapping of these rocks as the Mount Clarence Calcilutite Member of the Wavera Volcanics. The Godaguina Beds are considered redundant.

**WAVERA VOLCANICS (MACNAB 1967, AMENDED; Tmv) AND ADA’U LIMESTONE (MACNAB 1967, AMENDED SPELLING TO CONFORM WITH LOCAL USAGE; Tma)**

Macnab (1967) originally proposed the Wavera Volcanics for predominantly marine volcanic (pillow basalt) rocks cropping out in the headwaters of the Wavera River, east and west of the Kevery Valley and on the north and south fall of the Main Range. He nominated the Wavera River headwaters (148°45’E/9°55’S) as the type area. Macnab (1967) also mapped and described two limestone members within the Wavera Volcanics (Ada’u Limestone Member and Mount Clarence Calcilutite Member). Macnab (1967) assigned an early Miocene age to the Wavera Volcanics. In contrast, Davies & Smith (1974, p. 33) considered the Wavera Beds [sic.] to represent the Eocene part of the Kutu Volcanics with their map assigning all the pillow basalt sequence south of the Kevery Fault to the Upper Cretaceous–Eocene Kutu Volcanics. The Ada’u Limestone is a readily mappable unit and Davies & Smith (1974) elevated the limestone to formation status. With additional foraminiferal information available to Davies & Smith (1974), the age of the Ada’u Limestone was amended to early-middle Miocene. Davies & Smith’s (1974) revised status for the Ada’u Limestone has been adopted herein.

The Wavera Volcanics are recognised north of the Ada’u River and the Kevery Fault in the area between Doriri Creek and Urua Creek, and east from the Ea’u River into the Liba River catchment (Figure 4a), a significant difference from the mapping of Davies & Smith (1974). Good continuous exposure of the Wavera Volcanics is present along Oiso Creek and Urua Creek (Figures 4a, 5a). The volcanic formation has a distinctive total radiometric signal, readily distinguishing it from mafic and ultramafic rocks of the Awariobo Range Complex and adjacent formations (such as the Domara River Conglomerate). The Ada’u Limestone crops out as an 11 km-long fault sliver bounded to the north by the Kevery Fault and an unnamed fault to the south (Figure 4a). It underlies a prominent ESE-striking range of hills, with distinctive pinnacles and karst features especially to the west of old Ba’u village (Figure 5c). Shallow south dipping to vertical dips indicate localised tectonic disruption of the formation. The Mount Clarence Calcilutite Member crops out as a single stratigraphic horizon along the north fall of Mt Clarence (Macnab 1967), SW of the map area, and in the upper Godaguina Valley.

The Wavera Volcanics consist of fine-grained, reddish and dark brown basalt. Pillow structure is common in many outcrops throughout the Wavera. Ada’u, Liba, Amin and Ea’u valleys (Figure 5a, b). Terrestrial volcanic rocks, which include accretionary lapilli tuff, vesicular basalt and amygdaloidal basalt, have been identified in the Ada’u Valley at Urua Creek and Waki Creek. The volcanic rocks have an estimated thickness >730 m based on the difference in altitude between the highest and lowest exposures of the apparently horizontally bedded unit in the un faulted block in the Liba River area. The base of the Ada’u Limestone is not exposed. The formation has a minimum 440 m thickness based on the topographic limits of exposure of gently south-dipping beds west of old Ba’u village.

Breccias formed during mingling of pillow lavas of the Wavera Volcanics and the Ada’u Limestone are common in outcrop and float in the Wava, Ea’u, Amin and Ada’u valleys (see Figure 4a for occurrences), but neither Macnab (1967) nor Davies & Smith (1974) fully appreciated their significance. Field relations suggest the shallow-water emplacement of hot basalt pillow lava across a carbonate platform, resulting in shattered pillow basalt–limestone breccias. Good exposures of breccia are present in lower Urua Creek and upper Wavera River (Figure 5e, f) and as float in the Ada’u River (Figure 5d).

Macnab (1967) obtained Oligocene–Miocene foraminiferal age dates from limestone in the Wavera Volcanics in the Kevery Valley (vicinity of old Maré village, sample P1275) and G. C. H. Chaproniere (sample 15006; in Lindley & Tamu 1988) described the limestone breccias about a Ba’u village. Davies & Smith (1974) obtained a late Oligocene age on breccia outcrop in Urua Creek (Figure 5e). Field-rock relationships and biostratigraphy clearly indicate that the Wavera Volcanics and Ada’u Limestone are lateral equivalents. Foraminiferal biostratigraphic data indicate a late Oligocene–middle Miocene age for both formations.

The distribution of basalt–limestone breccias about a topographically anomalous 2 km² plateau, consisting of steep-sided semi-circular depressions filled with basalt scree and swamps, semicircular drainage patterns and basalt scree-covered steep escarpments on the Main Range between Waki Creek and Amin River (148°50.5’E/9°55’S) suggests this area may have been an erosive vent for the Wavera Volcanics.

**DOMARA RIVER CONGLOMERATE**

The Domara River Conglomerate crops out extensively in an approximately 400 km² area to the west of the map area in the Domara River, Poasi River and Musa Valley (Figure 2; Smith & Green 1981; Macnab 1967; Davies & Smith 1974). The conglomerate formation underlies much of the Kevery Valley, forming a distinctive
topography of low hills moderately dissected by numerous small streams. The unit does not extend north of the Keveri Fault (Figure 4a). The Domara River Conglomerate has a particularly distinctive intense total count radiometric airborne geophysical signature, making it easy to identify the outcrop limits of the formation. The formation in the Keveri Valley is a consolidated, coarse, poorly sorted polymictic conglomerate, with minor

Figure 5 Wavera Volcanics and Ada’u Limestone. (a) Pillow basalt in Urua Creek. (b) Pillow basalt in upper Wavera River. (c) Pinnacles of Ada’u Limestone in the Ada’u River, downstream from old Ba’u village. (d) Limestone and basalt breccia float, Ada’u River. (e) Limestone and basalt breccia outcrop in lower Urua Creek; foraminiferal age-date site 15006 (late Oligocene). (f) Limestone and basalt breccia on the Babauquina track, upper Wavera River.
sandstone and grey, weakly consolidated mudstone noted in Wavera River outcrops (Figure 6a–c). Conglomerate clasts include fine-grained mafic volcanic rocks, gabbro, monzonite, granite and harzburgite, apparently derived from erosion of the Awariobo Range Complex and other units to the north of the Keveri Fault. Clast size ranges up to 0.5 m. Clasts are set in a red-purplish lithic matrix, typical of non-marine deposition.

Rapid along-strike lateral facies changes are a feature of the formation in the Musa Valley (Smith & Green 1961). Macnab (1967) also noted cyclical deposition of conglomerate, sandstone and mudstone, probably a response to periodic source area uplift facilitated by movement along the Keveri Fault. Smith & Green (1961) and Macnab (1967) both noted carbonised wood up to 1 m long in poorly sorted boulder conglomerate.

Smith & Green (1961) collected four freshwater moluscan faunas (thin-shelled gastropods and occasional pelecypods) in calcareous mudstone in the Foasi River and Ikumu River about 20 km NW of the Keveri Valley. N. H. Ludbrook (in Smith & Green 1961) studied the collections and concluded a probable Pleistocene age for the Domara River Conglomerate. Ludbrook also concluded that the formation was deposited in lacustrine and piedmont environments. Macnab (1967) also collected freshwater thin-shelled gastropod faunas from thin carbonaceous and calcareous beds in the upper Domara River but none proved useful for dating.

Smith & Green (1961) mapped three basaltic–andesitic volcanic members near the base of the Domara River Conglomerate in the Musa Valley. They also noted interbedded lava flows at several localities in the Domara River and Foasi River and the presence of porphyritic andesitic dykes. Macnab (1967) also noted the basal volcanic phase and rare lava flows and/or sills. Davies & Smith (1974) used K–Ar ages of a related dyke (Bonua Porphyry?)—5.3 Ma) and a whole-rock determination on a volcanic clast (2.36 Ma) to conclude that the Domara River Conglomerate is Pliocene. Thus, paleontological and radiometric dating suggests the Domara River Conglomerate is of late Pliocene age, probably extending into the Pleistocene.

The Domara River Conglomerate is typically flat lying to gently dipping in the Keveri Valley. However, moderate 40–45° dips are typical of outcrop adjacent to the Keveri Fault (Figures 6a, 8b) with tilting of these rocks probably related to drag on the Keveri Fault. Similarly, moderately south-dipping beds are also very obvious in the Domara River area to the west of the map sheet (Figure 2). Smith & Green (1961) estimated a minimum thickness of 1800 m, and Davies & Smith (1974) estimated a 1500 m thickness for the formation. However, given its mode of deposition, thickness data for the Domara River Conglomerate are likely to be variable across the formation’s extensive outcrop area. The formation is unconformable on rocks of the Goropu Metamorphics in the Musa Valley (Smith & Green 1961; Smith & Davies 1976), the Owen Stanley Metamorphics in the upper Domara Valley (Lindley & Tamu 1986), and the Wavera Volcanics and Ada’u Limestone in the Keveri and Ada’u Valleys.

**SUCKLING GRANITE (Tmk)**

The Suckling Granite crops out in two stocks at the NE corner of the map area, about 5–10 km south and SW of the summit of Mt Suckling. These stocks cover 20 km² and include medium- and coarse-grained granite and adamellite (Davies & Smith 1974). The granite intrudes ultramafic rocks of the Awariobo Range Complex. The Suckling Granite is dated as late Miocene–early Pliocene by K–Ar determinations on hornblende (10.8, 9.43 Ma) and biotite (3.32, 3.24 Ma) (Davies & Smith 1974). Whole-rock analyses of the Suckling Granite indicate it to be calc-alkaline (Smith & Davies 1976).

The unroofing of Suckling Granite stocks in the summit area of Mt Suckling is evidence for very rapid rates of late Pliocene–Quaternary uplift and erosion for the Suckling Dome. Granites are rare in Papua New Guinea. Granite crops out on Mabaduan Hill near the southern coast of Western Province and on nearby small islands of the Torres Strait, and decomposed and light grey to white granite was intersected in oil wells at depths of 1888 m and 2971 m in the Arama River and Aworra River; respectively, both in Western Province (APC 1961). These occurrences are part of the crystalline Australian plate basement.

**MAI’IU MONZONITE (SYNONYMY: MAU MONZONITE; SMITH & DAVIES 1976; Tox)**

The Mai’iu Monzonite crops out in the NE corner of the map area. Davies & Smith (1974) mapped a single large stock of 150 km² in size SE of Mt Suckling (Figure 2). The monzonite stock consists of xenolithic granodiorite, biotite monzonite and biotite hornblende (Davies & Smith 1974). The monzonite is dated as late Miocene–early Pliocene on the basis of K–Ar age determinations on hornblende (6.26, 6.03, 4.37 Ma; Davies & Smith 1974). The stock intrudes ultramafic rocks of the Awariobo Range Complex and, east of the map area, the Goropu Metabasalt (Davies & Smith 1974). Whole-rock analyses of the Mai’iu Monzonite indicate it to be calc-alkaline (Smith & Davies 1976).

Two monzonite stocks intersected in deep drilling beneath diatreme breccia at Urua prospect, 21 km SW of the Mai’iu Monzonite stock, are considered related. Two distinct monzonite bodies were intersected in drilling, one an unaltered even-grained monzonite, the other an intensely epidote-altered monzonite with Au–Cu anomalous veins and stockwork veins of calciopryite–pyrite–magnetite. An unaltered, even-grained grey monzonite dyke was intersected during drilling of the footwall of the Doriri Ni–PGM lode.

**BONUA PORPHYRY (Tpb)**

Davies & Smith (1974) mapped a small diorite stock in a northern tributary of Oiyaku Creek, 2 km to the north of Paiwa village at the western end of the Keveri Valley. The stock is weakly argillically altered. The Oiyaku diorite body has a prominent airborne electromagnetic response (Goldminex Resources 2010). Diorite stocks are also present in Unu Creek to the south of Paiwa village (Lindley & Tamu 1986) and Omu Creek, SW of old Ba’u village. The Bonua Porphyry has an inferred late Miocene–early Pliocene age and is probably genetically related to the Suckling Granite and the Mai’iu Monzonite.
OTHER LATE MIocene–EARLY PLIOCENE INTRUSIVE AND RELATED ROCKS OF THE ADA’U VALLEY

Late Miocene–early Pliocene gabbro (Tg), diatreme breccia (Td), felsic dykes (Tf) and mafic dykes (Tm) have been mapped at several localities in the Ada’u Valley. These rocks are likely genetically related to the Suckling Granite and Mai’iu Monzonite.

At Urua, a diatreme breccia measuring 1700 m × 900 m and containing rare carbonised wood fragments is draped across the top of monzonite stocks intersected at depth during drilling. Mafic dykes and gabbro post-date
the emplacement of the diatreme. Pillow lava wallrock to the Urua diatreme in lower Urua Creek is dated using foraminifera as late Oligocene (G. C. H. Chaproniere in Lindley et al. 2010b), and is part of the late Oligocene-middle Miocene Wavera Volcanics/Ada’u Limestone sequence. These rock relationships constrain the age of the diatreme to late Miocene or younger. Other diatreme rocks in the Ada’u Valley have been mapped between Araboro and Dori creeks and at Ioleu Creek (Figure 4a). The Urua and Araboro diatreme breccias are associated with distinctive bright-red airborne radiogenic thorium anomalies. Interpretation of thorium imagery suggests another diatreme body is present 1.5 km SE of the Urua diatreme.

A swarm of NNE-trending porphyritic felsic dykes is present in Dimidi Creek, the largest measuring 300–500 m wide with a strike length of 2500 m (Figure 4a). These dykes have strong airborne radiogenic potassium anomalies. The dykes lie within the NNE-trending trans-island Dimidi structural trend, which passes along the length of Dimidi Creek.

Several small gabbro stocks (Tg) have been mapped at Urua Creek and Ioleu Creek. Mafic dykes have been mapped in the Ada’u River upstream of Doriri Creek where they intrude ultramafic rocks of the Awariobo Range Complex and, as noted above, post-date diatreme rocks at Urua. These dykes appear to be related to faults.

**QUATERNARY**

Quaternary deposits are widespread in lower elevations to the west and NW of the map area (Figure 2) and include the Ibau Breccia, Silimidi Conglomerate (with the Sivai Breccia Member) (all Pleistocene) and the Ubo and Wakioki fanglomerates (Holocene) (Smith & Green 1961; Davies & Smith 1974). Ultramafic breccia equivalents of the Ibau Breccia are recognised in the map area and floodplain, and terrace deposits of gravel, sand and mud are a feature of the broad, braided Ada’u River Valley. Gold-bearing gravels of the old Keveri Goldfield at Paiwa village are recognised as a new unit.

**ULTRAMAFIC BRECCIA DEPOSITS (Qu)**

Ultramafic breccias in the map area are restricted to the Ada’u Valley and the upper slopes of Mt Suckling. They are typically consolidated coarse to very coarse-grained and chaotically sorted deposits (Figure 7b). Clasts are angular to subangular, may be up to 0.75 m–1.0 m in size and are dominated by ultramafic rock. Breccias on the upper slopes of Mt Suckling have a sheet form. Valley-confined breccias have been mapped in Urua Creek and are particularly well exposed along the length of Dimidi Creek (Figure 4a). In some outcrops, cycles of sorting of very coarse breccia with medium–coarse breccia are obvious and attest to pulsating phases of uplift and vigorous erosion (Figure 7a). Interbedded planar-beded sandstone is also present in the Dimidi Creek breccias.

**ALLUVIAL TERRACE AND FLOODPLAIN DEPOSITS (Qa)**

Floodplain and gravel deposits of the Ada’u River and its northern tributaries are dominated by poorly to well-
 sorted gravels with sand and mud. The Ada’u River is a typical braided stream with active and inactive channels developed on a floodplain up to 400–500 m wide (Figure 8a). Voluminous quantities of gravel are sourced from the numerous northern tributaries of the Ada’u River that drain the rugged Awariobo Range (and flanks of the Suckling Dome), where elevations reach 2542 m (a local relief of 2100 m). These tributaries have very steep gradients and short fetches. Rainfall tends to be localised and is characterised by extreme precipitation over a short time period. Accordingly, stream flows rapidly fluctuate, and floods are of short duration.

Older terraces are preserved at progressively higher levels above the Ada’u floodplain along the entire length of the river. Terraces are particularly prominent on the north bank of the Ada’u River at Doriri Creek, immediately downstream of Uruna Creek and the Urua Creek flats near old Bai’u village.

LANDSLIDE DEPOSITS
Landslide deposits are widespread on the over-steepened slopes of the Awariobo Range, particularly in the upper reaches of the Urua and Dimidi valleys and are too numerous to be shown on the geological map (Figure 4a).

PAIWA GRAVELS (NEW NAME; Qp)
The Paiwa Gravels crop out at Paiwa village on the lower Wavera River. It was at this locality that the Keveri Goldfield was proclaimed on 6 August 1904, following Frank and Dan Pryke’s discovery of gold in 1902. Most of the mining activity had subsided by 1907, and since 1926 there has been little recorded production from the field. The field produced a total of 5903 ounces of gold most of which was recovered during 1904–1905. The resurgence in the gold price during the past 10 years has seen the reoccupation of Paiwa village and a resumption of alluvial mining by Keveri landowners from Amau village using portable sluicing equipment. Localised high temperature and pressure conditions along the fault.

The Paiwa Gravels were deposited in an alluvial fan bordering the frontal ranges of an actively uplifting source area of Wavera Volcanics. Variations in the unit’s distinctive detrital mineral assemblage, clay content and coarseness indicate a source area immediately SW of the Keveri Valley. The presence of gravels with a clay-rich matrix indicates poor sorting and rapid sedimentation. The coarseness of the bimodal detrital augite and hornblende grains indicates source-area proximity. The composition of both the detrital assemblage and gravel clasts indicates a basalt volcanic provenance (Wavera Volcanics) with minor diorite intrusive rock (Bonua Porphyry). An unusual detrital assemblage in the gravel fan north of Oiyaku Creek suggests the development of a separately sourced gravel sheet adjacent to the main Paiwa basin. The northern extent of this fan is unknown.

STRUCTURE

Inversion modelling of total magnetic intensity data
The Keveri Fault, Nonia Fault (new name) and several unnamed flanking faults of the Wavera Valley cross the map area. A 2010 helicopter-borne detailed low-level airborne geophysical survey covered an 8 km swathe along a 30 km interval of the Keveri Fault (Figure 9a). Inversion modelling of total magnetic intensity (TMI) data is a computer-based analysis aimed to focus on deeper magnetic bodies (up to 7–10 km depth) in preference to smaller shallower sources. Surface traces of significant faults and formational boundaries are superimposed on the inversion model (Figure 9b). The traces of the Keveri and Nonia faults when projected vertically closely coincide with the boundaries of deep magnetic bodies identified by modelling, indicating these faults are vertical.

Keveri Fault (Synonymy: Keveri Fault System; Davies & Smith 1974)
The Keveri Fault is marked by the aligned streams and broad valley floors of the braided Ada’u River and the Domara River. The fault’s trace in the Ada’u Valley is marked by an abrupt step in elevation immediately north of the river. The land surface rises sharply to the 3676 m high Mt Suckling. Truncated ridges and terraces in Holocene gravels in the Ada’u Valley and the deflection of drainage channels in Holocene gravels (e.g. the Ada’u River channel and Dimidi Creek) also mark the fault and indicate dextral strike-slip movement (Figure 8a, c). Fault-bounded blocks of the Wavera Volcanics and the Ada’u Limestone occur in the trace of the fault, especially in the Urua Creek area. Tremolite within yellowish serpentine boulders in the I’ve Creek at the western end of the Keveri Valley (148°43′E/9°31′S; Figure 4a) indicate localised high temperature and pressure conditions along the fault.

The Keveri Fault has been interpreted as a thrust fault, at least during its early history, based one or more of the following (1) theoretical grounds; (2) extrapolation of structural interpretations of the OSFZ from elsewhere.
in eastern Papua; and (3) perpetuation of ideas originating from reconnaissance geological mapping completed more than 45 years ago. During my intensive traversing and mapping of streams running the length and breadth of the Keveri Fault, no structural features (joints, fractures, faults, slicken-sided surfaces) have been observed that suggest the former presence of a low-angle structure (Figure 4a). Daczko et al. (2011) made a similar observation in the Mt Dayman area, ESE of Mt Suckling. Field geological observations are supported by subsurface geophysics (inversion modelling of total magnetic intensity survey data) that clearly indicate the Keveri Fault is vertical to depths of up to 7–10 km (Figure 9b). Rock relationships, in particular the mapped distribution of Wavera Volcanics both north and south of the Keveri Fault, indicate that movement along the fault was initiated post-middle Miocene. To account for these observations, I suggest the formation of the Keveri Fault is unrelated to the OSFZ and post-dated the late Paleogene (ca 58 Ma) thrust emplacement of the PUB and that development of the Keveri Fault is linked to the late Miocene intrusion of granite (Suckling Granite) and the commencement of buoyant uplift of the Suckling Dome.

Uplift rates on the Keveri Fault can be estimated from the Suckling Granite, which crops out near the summit of Mt Suckling. The granite is dated between 9.4 and 3.3 Ma and, assuming a depth of emplacement of around 4 km (Lynn et al. 1981), an uplift rate along the Keveri Fault of 8000 m during the past 5 Ma (2.5 m/10^3 a) is indicated. High rates of erosion associated with the uplift of Mt Suckling are manifest by braided streams, alluvial terraces, ultramafic breccias, and landslide and scree deposits. For comparison, rates of uplift along the Alpine Fault in New Zealand are estimated at between 9000 and 14 000 m during a 6 Ma period (1.5–2.3 m/10^3 a; Suggate 1983). Moderately tilted, south-dipping units of the Domara River Conglomerate adjacent to the Keveri Fault are a response to drag on the fault (Figures 6a, 8b).
Strike-slip rates can be estimated from the dextral offset of the Dimidi Creek channel at its confluence with the Ada’u River (Figure 8c). If the 300 m offset occurred during the Holocene (past 0.01 Ma), the Keveri Fault has slipped dextrally at a rate of 30 m/10^3 a. A similar rate of movement is also obtained for the dextral offset of the Ada’u River channel at 14° 47'E/9° 52.5'S.

The map area has experienced low levels of seismicity (Brooks 1965; Ripper & Letz 1991; ISC 2013), but in the period 1964–1989 two shallow (0–39 km depth) M5.0–5.9 events originated within the map area (Ripper & Letz 1991; Figure 4g). Both events plot along the Keveri Fault indicating the fault remains active and may present a seismic hazard.

Figure 9 Inversion modelling of total magnetic intensity data along the Keveri Fault and Nonia Fault with selected geology. (a) Total magnetic intensity survey data from the 2010 Mt Suckling/Keveri Fault helicopter-borne detailed low-level geophysical survey. (b) Inversion model along the Keveri Fault (after R. Palmer, PGC Geophysics Consulting, Brisbane). The aim of inversion modelling is to focus on deeper magnetic bodies in preference to smaller shallower sources. Surface traces of the Keveri and Nonia faults (black lines) closely correspond with the boundaries of magnetic bodies identified at depth, indicating these faults project vertically to depths of at least 7–10 km. Approximate boundaries of mapped geological formations are shown thus: yellow, Domara River Conglomerate; blue, Ada’u Limestone; pink, Goropu Metabasalt; orange, Wavera Volcanics north of the Keveri Fault.
Nonia Fault (New name)

The Nonia Fault is a prominent northern splay of the Keveri Fault. The fault has a length of 21 km, and its trace is obvious on total count radiometric imagery. For much of its length, it separates Goropu Metabasalt from ultramafic rocks of the Awariboe Range Complex. At the fault’s western end, it forms a series of intermontane basins (late Pliocene—early Pleistocene? Domara River Conglomerate; Holocene Paiwa Gravels). Well-developed horizontal slickensides exposed in the Wavera River, 1.5 km south of old Maré village, indicate that strike-slip movement also occurred along the Wavera Valley faults. Post-depositional strike-slip offset of the Domara River Conglomerate in the map area suggests some of this dextral strike-slip movement has occurred since the early Pleistocene.

Dimidi Trend (New name)

The Dimidi Trend is a previously unrecognised trans-island structure (Figure 2) that follows Dimidi Creek, where wide zones of rock, strongly fractured in a SSW–NNE direction, crop out. Adjacent Araboro Creek and Urua Creek drainages also parallel the Dimidi Trend. The structure has been an important control on late Oligocene–Holocene magmatism and volcanism with the following igneous events spatially linked to the Dimidi Trend: (a) late Oligocene–middle Miocene Wavera Volcanics are localised near the intersection of the Dimidi Trend with the Keveri Fault; (b) late Miocene–early Pliocene diatreme breccia at Urua Creek (and most likely Araboro Creek) lies within the Dimidi Trend; (c) late Miocene–early Pliocene emplacement of monzonite and diorite stocks at Urua Creek and Omu Creek; (d) late Miocene–early Pliocene emplacement of Dimidi Trend-parallel gabbro stocks at Urua Creek and Ioleu Creek; (e) Emplacement of a NNE-trending porphyritic felsic dyke swarm in Dimidi Creek; (f) late Miocene–early Pliocene emplacement of Suckling Granite; (g) late Miocene–early Pliocene emplacement of the Mal’iu Monzonite; (h) Pleistocene eruption of Mt Trafalgar volcano; (i) Holocene eruption of Mt Victory volcano (1890, 1930s); and (j) Holocene eruption of Goropu crater (1943–1944). The Cu–Au-bearing Urua and Omu intrusive stocks and the Doriri hydrothermal Ni–PGM prospect (González-Alvarez et al. 2013) are localised in the Keveri Fault near its intersection with the Dimidi Trend.

Other faults to the south of the Keveri Fault

Keveri Fault-parallel structures are developed along the southern edge of the Wavera Valley (Figure 4a). The formation of a succession of intermontane basins was a response to uplift of the Main Range (south of the Wavera faults) and the Suckling Dome (north of the Keveri Fault). Piedmont and lacustrine sediments filled the intermontane basins (late Pliocene—early Pleistocene? Domara River Conglomerate; Holocene Paiwa Gravels). Well-developed horizontal slickensides exposed in the Wavera River, 1.5 km south of old Maré village, indicate that strike-slip movement also occurred along the Wavera Valley faults. Post-depositional strike-slip offset of the Domara River Conglomerate in the map area suggests some of this dextral strike-slip movement has occurred since the early Pleistocene.

SYNTHESIS AND CONCLUSIONS

Suckling Dome (New name)

BUOYANT UPLIFT MODEL

Ollier & Pain (1980, 1981) proposed a model of buoyant uplift triggered by granite pluton emplacement in regions of thick crust undergoing extension to account for the origin of eastern Papuan metamorphic core complexes including the Dayman Dome. Their model readily accounts for the geology and tectonics of the Suckling Dome. The presence on the summit of the Suckling Dome of granite (Suckling Granite) and monzonite (Mal’iu Monzonite) stocks (Figures 2, 4b) that have intruded strongly fractured and cleaved metamorphosed basalts (Goropu Metabasalt; Lindley 1992) is compelling evidence for buoyancy-driven uplift. I propose that the late Miocene intrusion of a granite diapir (precursor to the Suckling Granite) into the thick crust of the eastern Papua region (Milsom & Smith 1975) and the initiation of buoyant uplift of the Suckling Dome was the beginning of a cycle of tectonic instability that continues to the present. The rising granite body was responsible for metamorphism and foliation of overlying rock, a feature noted in other eastern Papuan domes (Ollier & Pain 1980). In turn, the foliated and brittle carapace was thrust upwards by the buoyant driving force of a much larger granite batholith, eventually breaking through ground surface as a surficial dome. The initiation of buoyant uplift of the Suckling Dome coincided with the commencement of Woodlark rifting (Taylor et al. 1999).

TOPOGRAPHY

The broad 3676 m high Suckling Dome (Figures 4b, 11, 12) is well dissected. Northern and NW flanks are relatively intact, but faulting and erosion have obscured the western and southern slopes (Figure 11). The contrasting topography of the northern slopes of the Suckling Dome and Dayman Dome (evident on the SAFIA and DAIMAN 1:100 000 topographic maps) suggests the former to be an older structure. Many subparallel streams drain the slopes of the Dayman Dome (Ollier & Pain 1980, 1981; Daczko et al. 2011). Increased dissection of higher slopes of the Dayman Dome, the result of more erosion, is evident while the lower slopes are less weathered (Ollier & Pain 1980, 1981). By contrast, well-developed network drainage has dissected both the lower and upper slopes of the Suckling Dome (Figure 11), indicating considerably more erosion and the longevity of the dome structure.

Taje, R., 2014. "Suckling Dome, eastern Papua." In R. Taje (Ed.), "Taje_10_2014".
Figure 10 Nonia Fault. Geological map of serpentine rocks in the Nonia Fault, Dimidi Creek.
DOME DEVELOPMENT

The Keveri Fault facilitated most of the rapid vertical movement on the southern margin of the Suckling Dome, with an estimated 8000 m of uplift since the late Miocene, at a rate of around 2.5 m/10^3 a. The vertical movement on the Keveri Fault is notably different from that described for structures flanking other eastern Papua metamorphic core complexes. Detachment faults are present along the northern margin of the Suckling Dome, Dayman Dome and the D’Entrecasteaux domes (Ollier & Pain 1980, 1981; Hill et al. 1992; Hill & Baldwin 1993; Daczko et al. 2011; Little et al. 2011). There is no field evidence for the development of a low-angle, south-dipping detachment fault along the southern margin of the Suckling Dome.

Episodic and very energetic uplift of the Suckling Dome continued during the late Pliocene–early

Figure 11 Suckling Dome. Topographic map of the dome, contour interval 200 m. Base map from Tufi, Papua New Guinea—1:250 000 Joint Operations Graphic, Sheet SC55-8.
Pleistocene. Flanking subsidiary faults to the Keveri Fault in the Wavera Valley were activated, forming an intermontane basin in the Keveri Valley. Rapid uplift and erosion resulted in the cyclical deposition of poorly sorted gravel and sandstone (Domara River Conglomerate) in the intermontane basin and the development of extensive piedmont fan complexes covering a 400 km² area west and NW of Mt Suckling (Figure 2). Estimated thicknesses of non-marine sediment deposited in the fan complexes vary between 1500 and 1600 m. Rapid uplift during the Quaternary, with movement continuing to be accommodated along the Keveri Fault, resulted in localised tilting and displacement of the Domara River Conglomerate. Dextral strike-slip motion along the Wavera Valley faults displaced the Domara River Conglomerate and, along the Keveri Fault, offset tributaries of the Ada'u River. Rapid erosion associated with the vigorous uplift of Mt Suckling to its present height resulted in the unroofing of high-level granite (Suckling Granite) and monzonite (Mai'iu Monzonite) apophyses connected at depth to the granite diapir(s) that initiated buoyant uplift (Figures 2, 4b). Valley-confined ultramafic breccia deposits in Dimidi Creek, on the SW flanks of the Suckling Dome, attest to repeated cycles of vigorous uplift. Farther to the west and NW, extensive and thick Quaternary sediments in the Musa Valley include fanglomerate (Silimidi Conglomerate, up to 500 m thick; Ubo and Wakioki fanglomerates, up to 50 m thick) and sheet-like ultramafic breccia deposits (Ibau Breccia, up to 150 m thick). The gold-bearing Paiwa Gravels were deposited in a small alluvial fan in the western Keveri Valley. The 11 Ma cycle of granite intrusion, uplift and erosion of the Suckling Dome compares with an estimated 20 Ma for the Paparoa Metamorphic Core Complex, Westland, New Zealand (Nathan et al. 2002).

Keveri Fault and the Owen Stanley Fault System

Geophysical data, and in particular gravity, are very clear in showing that the OSFZ (and the PUB) passes north of the Mt Suckling district into Collingwood Bay. Gravity data also indicates that the PUB as an intact coherent body is not present east of 149°30′E. Movement on the Keveri Fault commenced in the late Miocene with the initiation of buoyant uplift of the Suckling Dome. Regional BMR mapping indicates that the western extension of the Keveri Fault in the 148°15′E to 148°40′E interval is represented by a series of splays (Figure 2; Davies & Smith 1974; Pieters 1978), suggesting that maximum movement occurred along the Ada’u Valley interval of the fault as uplift of the Suckling Dome progressed. There is no obvious connection between the western extensions of the Keveri Fault and the OSFZ. Both structures are subparallel and may be part of a broad zone of shearing. East of the Ada’u Valley, the trace of the Keveri Fault is prominent in the Bonua Valley, underlying the broad sediment filled valley (149°08′E/9°56′S) and...
controlling the course of the river and Iau'doe Creek, a large western tributary (Figure 2).

**ACKNOWLEDGEMENTS**

The author is grateful to three AJES reviewers for their comments; the constructive criticisms of Nathan Daczko and an anonymous reviewer were particularly important in improving the overall readability of my manuscript. Ken Campbell is thanked for his comments on the final text. Hugh Davies is thanked for his thoughts on chromitite rocks in Dimidi Creek and their absence in the PUB; Richard Hughes mapped the felsic dykes in Dimidi Creek; George Chaproniere worked on the Ada’u Limestone biostratigraphic samples; Wolfgang Maier discussed his ideas on PGM occurrence in the PUB and the possible relationship of the Sadowa batholith with mineralisation; Ron Palmer, PGC Geophysical Consulting, Brisbane, produced an inversion model of TMI data (Figure 9b) and the base for the 1:50,000 geological map (Figure 4a); and Kevin McCue provided earthquake data for the Mt Suckling district. Cliff Ollier, Colin Pain and Ignacio González-Alvarez kindly reviewed early drafts of the manuscript. Fieldwork would not have been possible without the support of the landowning Ba and Keveri clans of Doma, Amau and Baiobo villages, inland Cloudy Bay district, Central Province. Many times our small exploration teams consisted only of villagers and myself. The support over the years of Elvin Nobake from Doma has been especially important. And thanks to the many helicopter pilots who skillfully managed to cross the Main Range despite the weather, especially David Inau who in 1992 landed me on one of the Mt Suckling peaks at an altitude of 11 028 ft and near the limits of our Hughes 500D helicopter.

**SUPPLEMENTARY PAPER**

Geological map of the Keveri and Ada’u Valleys, eastern Papua. Geological cross-section from Badu Mountain to Mt Suckling showing the Suckling Dome. Vertical exaggeration 1:1.

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APPENDIX

FIELD MAPPING AND DATA SOURCES

There has been little advancement in stratigraphic mapping of eastern Papua despite the region being the focus of recent research. J. W. Smith & D. H. Green completed the first systematic geological survey in 1958 in the Musa Valley (Smith & Green 1961). Mapping, classed as reconnaissance only and directed towards the production of the 1:250 000 scale geological map series (Davies 1978; C. Pigram pers. comm. 2014), was completed between 1965 and 1968 by the BMR with contributions from H. L. Davies, I. E. M. Smith, R. P. Macnab, G. Cifali, R. J. Tingeys, P. D. Hohnen, P. E. Pieters, C. D. Ollier (all BMR) and W. Manser (University of Papua New Guinea) (Davies & Smith 1974; Smith & Davies 1976). R. P. Macnab produced a 1:63 360 geological map of the Keveri Valley and parts of the Ada’u Valley during fieldwork in April–May 1966 (Macnab 1967). Subsequent mapping contributions in the PUB have focussed on specific geological issues (e.g. Worthing 1988; Lus et al. 2004; Daczko et al. 2011).

Data used in the preparation of the 1:50 000 geological map (Figure 4a) include: (a) district-wide 1:20 000 mapping completed in all major streams, including the Ada’u, Du’ubo, Ea’u, Wavera, Amin, Liba and upper Domara Rivers and Dimidi, Urua, Waki, Omu, Yokai, Oiso, Doriri and Ioleu Creeks; (b) results from a detailed low-level airborne magnetic and radiometric geophysical survey of the Ada’u Valley (200 m flight line spacing; 60 m nominal mean terrain clearance), acquired in December 2010; (c) inversion modelling of TMI data by R. Palmer, PGC Geophysics Consulting, Brisbane; (d) detailed 1:500/1:1000/1:2000 mapping of the many mineral prospects in the Ada’u and Keveri Valleys; (e) 1:100 000 Skaipiska series black and white vertical aerial photography, acquired in August 1973; (f) information from 3D-induced polarisation ground geophysical surveys completed on the Urua Au–Cu and Ioleu Creek Au–Cu prospects in 2011; (g) subsurface information obtained from deep cored drilling at Urua prospect (three drill holes) and Doriri Ni–PGM prospect (four drill holes) in 2012; (h) PGM geochemistry from exploration programs completed since 1966; and (i) results from the GSPNG and BGS 1:2 500 000 compilation of gravity mapping of PNG, completed in 2004.