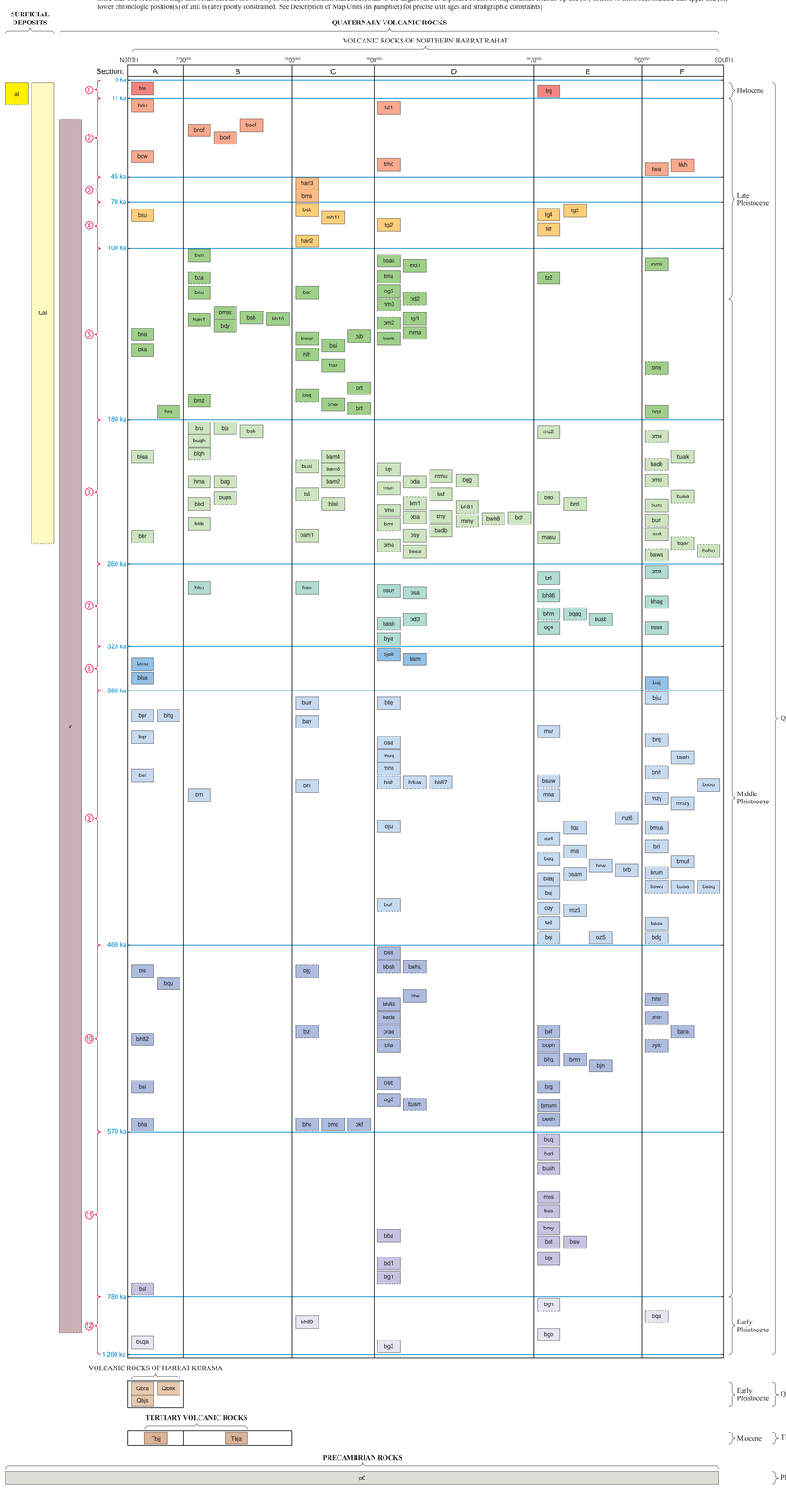
U.S. Department of the Interior
U.S. Geological Survey

U.S. Geological Survey Scientific Investigations Map 3428
Saudi Geological Survey Special Report SGS–SP–2019–2
Sheet 4 of 4
Pamphlet accompanies map

CORRELATION OF MAP UNITS

[Map is divided into sections to help locate units; capital letters A–F correspond to sections (from north to south, respectively) where units can be found on map; locations of section dividers on map are indicated by UTM coordinates (as northing values); northing values are in UTM Zone 37N coordinate system, WGS1984 datum. Quaternary volcanic rocks consist of undifferentiated vents (v), volcanic rocks of northern Harrat Rahat volcanic field, and volcanic rocks of Harrat Kurama. Volcanic rocks of northern Harrat Rahat volcanic field are arranged, vertically, in stratigraphic and chronological order within eruptive stages and, horizontally, within section columns. Red circled numbers indicate eruptive stages (stage 1, youngest; stage 12, oldest) within northern Harrat Rahat volcanic field, and red brackets indicate their age ranges; blue lines and type show approximate ages of eruptive-stage boundaries. Volcanic rocks not associated with northern Harrat Rahat volcanic field are subdivided into volcanic rocks of Harrat Kurama (Qbhk, Qbjs, Qbra) and Tertiary volcanic rocks (Tbja, Tbj). Note that, although some units may span more than one section on map, unit boxes here are shown only in the section column that corresponds to the largest surface exposure of unit on map. Dashed lines at top and (or) bottom of unit boxes indicate that upper and (or) lower chronologic position(s) of unit is (are) poorly constrained. See Description of Map Units (in pamphlet) for precise unit ages and stratigraphic constraints]



LIST OF MAP UNITS

[Map units are divided into surficial deposits, Quaternary volcanic rocks, Tertiary volcanic rocks, and Precambrian rocks. Surficial deposits are listed alphabetically by unit symbol. Quaternary volcanic rocks consist of undifferentiated vents (v), volcanic rocks of northern Harrat Rahat volcanic field, and volcanic rocks of Harrat Kurama. Volcanic rocks of northern Harrat Rahat volcanic field are subdivided into 12 eruptive stages (stage 1, youngest; stage 12, oldest); within each eruptive stage, units are listed alphabetically by unit symbol; first letter of unit symbol indicates composition of unit (b, basalt; h, hawaiite; rh, mugearite; o, benmoreite; t, trachyte). Volcanic rocks not associated with northern Harrat Rahat volcanic field are subdivided into volcanic rocks of Harrat Kurama (Qbhk, Qbjs, Qbra) and Tertiary volcanic rocks (Tbja, Tbj); these units also are listed alphabetically by unit symbol. Undifferentiated Precambrian rocks are labeled as pC. Map is divided into sections to help locate units; capital letters and numbers (in brackets after each unit age) correspond to sections where units can be found on map (see fig. 3). See Correlation of Map Units for relative ages of units. See Description of Map Units (in pamphlet) for complete unit descriptions. Tiny, unlabeled polygons are identified in database]

SURFICIAL DEPOSITS

al — **Modern alluvium (Quaternary)** [A1, A2, B1, C1, D1, E1, F1]

Qal — **Alluvium (Quaternary)** [A1, A2, B1, B2, C1, C2, D1, D2, E1, E2, F1, F2]

QUATERNARY VOLCANIC ROCKS

v — **Undifferentiated vents (Quaternary)** [A1, A2, B1, B2, C1, C2, D1, D2, E1, E2, F1, F2]

VOLCANIC ROCKS OF NORTHERN HARRAT RAHAT

Eruptive Stage 1 (0 to 11 ka)

bla — **Basalt of Al Labah (Holocene)** [A1, B1]

trg — **Trachyte of Um Rgaibah (Holocene)** [E2]

Eruptive Stage 2 (11 to 45 ka)

bcef — **Basalt of Central Finger (late Pleistocene)** [A2, B2]

bdu — **Basalt of Al Du'aythah (late Pleistocene)** [A1, B1]

bdw — **Basalt of Ad Duwaykhilah (late Pleistocene)** [A1, B1]

bnof — **Basalt of Northern Fingers (late Pleistocene)** [A1, A2, B1, B2]

bsof — **Basalt of Southern Fingers (late Pleistocene)** [B2, C2]

hkh — **Hawaiite of Khamisah (late Pleistocene)** [F2]

td1 — **Trachyte of Dabaa 1 (late Pleistocene)** [D2]

tmo — **Trachyte of Mouteen (late Pleistocene)** [D2]

twa — **Trachyte of Al Wabarah (late Pleistocene)** [F2]

Eruptive Stage 3 (45 to 70 ka)

bms — **Basalt of Musawda'ah (late Pleistocene)** [C1, C2, D1, D2]

han3 — **Hawaiite of Al Anahi 3 (late Pleistocene)** [B1, C1, C2, D1]

Eruptive Stage 4 (70 to 100 ka)

bsk — **Basalt of Sha'ib Al Khakh (late Pleistocene)** [B1, C1]

bsu — **Basalt of As Suddiyah (late Pleistocene)** [A1]

han2 — **Hawaiite of Al Anahi 2 (late Pleistocene)** [B1, C1]

mh11 — **Mugearite of Hill 1125 (late Pleistocene)** [B1, C1, C2]

tef — **Trachyte of Al Efairia (late Pleistocene)** [E2, F2]

tg2 — **Trachyte of Gura 2 (late Pleistocene)** [D2]

tg4 — **Trachyte of Gura 4 (late Pleistocene)** [D2, E2]

tg5 — **Trachyte of Gura 5 (late Pleistocene)** [E2]

Eruptive Stage 5 (100 to 180 ka)

bar — **Basalt of Abu Rimthah (late Pleistocene)** [C2]

bdy — **Basalt of Ad Dubaysiyah (middle Pleistocene)** [B1, B2, C1, C2]

bh10 — **Basalt of Hill 1066 (middle Pleistocene)** [B2, C2]

bjb — **Basalt of Al Janubi (middle Pleistocene)** [C2, D2]

bka — **Basalt of Al Khanaq (middle Pleistocene)** [A1, A2]

bm2 — **Basalt of Al Malsaa 2 (late or middle Pleistocene)** [D2]

bmz — **Basalt of Mahd Adh Thahab Road (middle Pleistocene)** [A1, B1]

bmaf — **Basalt of Al Muzayyin (middle Pleistocene)** [B1]

bna — **Basalt of Nabta (middle Pleistocene)** [A2, B2]

bnar — **Basalt north of Abu Rimthah (middle Pleistocene)** [C2]

bns — **Basalt of Nashbah (middle Pleistocene)** [F1, F2]

bnu — **Basalt of Nubala (late Pleistocene)** [B1]

bra — **Basalt of Al Rafi'ah (middle Pleistocene)** [A1, B1]

brt — **Basalt of Radio Tower (middle Pleistocene)** [C2]

bsas — **Basalt of Shai'ab Abu Sikhbir (late Pleistocene)** [C2, D2]

bsb — **Basalt of Sha'ib Banthane (middle Pleistocene)** [B1, C1]

bsi — **Basalt of Sha'ib Iskabah (middle Pleistocene)** [C2]

bsq — **Basalt of Ash Suqaysiqah (middle Pleistocene)** [C1]

bun — **Basalt of Umm Nathilah (late Pleistocene)** [B1, C1]

bwar — **Basalt west of Abu Rimthah (middle Pleistocene)** [C2]

bwm — **Basalt west of Matan (middle Pleistocene)** [C2, D1, D2]

bza — **Basalt of Az Zanat (late Pleistocene)** [B2]

han1 — **Hawaiite of Al Anahi 1 (middle Pleistocene)** [A1, B1, C1, C2]

har — **Hawaiite of Abu Rimthah (middle Pleistocene)** [C2]

hd2 — **Hawaiite of Dabaa 2 (late or middle Pleistocene)** [D2, E2]

hih — **Hawaiite of Al Lihyan (middle Pleistocene)** [B2, C2]

hm3 — **Hawaiite of Al Malsaa 3 (middle Pleistocene)** [D2]

md1 — **Mugearite of Dabaa 1 (late Pleistocene)** [C2, D2]

mma — **Mugearite of Matan (middle Pleistocene)** [C2, D1, D2]

mmk — **Mugearite of Mukhayar (late Pleistocene)** [E2, F2]

og2 — **Benmoreite of Gura 2 (late Pleistocene)** [D2]

oqa — **Benmoreite of Al Qara'in (middle Pleistocene)** [F2]

ort — **Benmoreite of Radio Tower (middle Pleistocene)** [C2]

tg3 — **Trachyte of Gura 3 (middle Pleistocene)** [D2]

tma — **Trachyte of Matan (late Pleistocene)** [C2, D2]

tz2 — **Trachyte of Um Znabah 2 (late Pleistocene)** [E2]

Eruptive Stage 6 (180 to 260 ka)

badb — **Basalt of Al Adhbah (middle Pleistocene)** [D1]

badh — **Basalt of Adh Dhiyabah (middle Pleistocene)** [F2]

bag — **Basalt of Abu Ghuwayshiyah (middle Pleistocene)** [B2, C2]

bahu — **Basalt of Al Hulays (middle Pleistocene)** [F2]

bam1 — **Basalt of Amlit 1 (middle Pleistocene)** [C2]

bam2 — **Basalt of Amlit 2 (middle Pleistocene)** [C2]

bam3 — **Basalt of Amlit 3 (middle Pleistocene)** [C2]

bam4 — **Basalt of Amlit 4 (middle Pleistocene)** [C2]

bawa — **Basalt of Al Wabarah (middle Pleistocene)** [F2]

bbd — **Basalt of Banthane Dam (middle Pleistocene)** [B1]

bbr — **Basalt of Al Buraysha (middle Pleistocene)** [A2]

bda — **Basalt of Ad Darah (middle Pleistocene)** [D2]

bdr — **Basalt of Dab Al Harus (middle Pleistocene)** [D1, E1]

besa — **Basalt east of Al Shathaa (middle Pleistocene)** [D2]

bhf1 — **Basalt of Hill 810 (middle Pleistocene)** [D1]

bhh — **Basalt of Hamra Al Bidun (middle Pleistocene)** [A2, B2]

bhy — **Basalt of Sha'ib Hayaya (middle Pleistocene)** [D2]

bjr — **Basalt of Umm Jurmat (middle Pleistocene)** [D1, E1]

bjs — **Basalt of Al Jassah (middle Pleistocene)** [B1]

bli — **Basalt of Al Billa'ah (middle Pleistocene)** [C2]

blqa — **Basalt of Lower Qa Al Aqul (middle Pleistocene)** [A1, A2]

blqh — **Basalt of Lower Qa Hadawda (middle Pleistocene)** [B2, C2]

blsl — **Basalt of Lower Sha'ib Libyan (middle Pleistocene)** [C2]

bm1 — **Basalt of Al Malsaa 1 (middle Pleistocene)** [D2]

bmd — **Basalt of Al Madba'ah (middle Pleistocene)** [F1, F2]

bme — **Basalt of Al Mesba'ah (middle Pleistocene)** [F2]

bml — **Basalt of Al Mulaysa (middle Pleistocene)** [E1, F1]

bmt — **Basalt of Matan (middle Pleistocene)** [C2, D2]

bqar — **Basalt of Al Qara'in (middle Pleistocene)** [F2]

bqg — **Basalt of Qa Al Ghusun (middle Pleistocene)** [C1, D1]

bru — **Basalt of Ar Rummanah (middle Pleistocene)** [A1, B1]

bsf — **Basalt of Umm Sufar (middle Pleistocene)** [D1, E1]

bsh — **Basalt of Shuran (middle Pleistocene)** [A1, B1, C1]

bso — **Basalt of South (middle Pleistocene)** [E1]

bsy — **Basalt of Abu Siyilah (middle Pleistocene)** [C1, D1]

buaa — **Basalt of Umm Al Awshaz (middle Pleistocene)** [F1]

buak — **Basalt of Umm Arakah (middle Pleistocene)** [F1, F2]

bups — **Basalt of Upper Sahab (middle Pleistocene)** [B2]

buqh — **Basalt of Upper Qa Hadawda (middle Pleistocene)** [B2]

burl — **Basalt of Upper Ar Ritajah (middle Pleistocene)** [F2]

buru — **Basalt of Umm Rutaj (middle Pleistocene)** [F2]

busi — **Basalt of Upper Sha'ib Iskabah (middle Pleistocene)** [C2]

bwh8 — **Basalt west of Hill 870 (middle Pleistocene)** [D1]

hma — **Hawaiite of Al Malsa (middle Pleistocene)** [A1, A2, B1, B2]

hmk — **Hawaiite of Mukhayar (middle Pleistocene)** [E2, F2]

hmo — **Hawaiite of Mouteen (middle Pleistocene)** [C2, D2]

masu — **Mugearite of As Sumak (middle Pleistocene)** [E2, F2]

mmu — **Mugearite of Al Mulaysa (middle Pleistocene)** [D2]

mmy — **Mugearite of Murayyikh (middle Pleistocene)** [D2]

murr — **Mugearite of Umm Ar Rish (middle Pleistocene)** [D1, D2]

mz2 — **Mugearite of Um Znabah 2 (middle Pleistocene)** [D2, E2]

oba — **Benmoreite of Al Bayadah (middle Pleistocene)** [D2]

oma — **Benmoreite of Al Malsaa (middle Pleistocene)** [D2]

Eruptive Stage 7 (260 to 323 ka)

bash — **Basalt of Ash Shamali (middle Pleistocene)** [D1]

bau — **Basalt of An Nughayr (middle Pleistocene)** [B1, C1]

bd3 — **Basalt of Dabaa 3 (middle Pleistocene)** [D2, E2]

bh86 — **Basalt of Hill 865 (middle Pleistocene)** [D1, E1]

bhag — **Basalt of Hilayyat Ghuwayshiyah (middle Pleistocene)** [E1, F1, F2]

bhm — **Basalt of Al Humayra (middle Pleistocene)** [E2]

bhu — **Basalt of Al Huzaym (middle Pleistocene)** [A1, B1]

bmk — **Basalt of Mukhayar (middle Pleistocene)** [F2]

bqaq — **Basalt of Qa Al Qina'ah (middle Pleistocene)** [E1, F1]

bsa — **Basalt of Al Shathaa (middle Pleistocene)** [D2]

bssu — **Basalt south of As Sumak (middle Pleistocene)** [E2, F2]

bsuy — **Basalt of Umm Suyuf (middle Pleistocene)** [D1]

busb — **Basalt of Al Usbu'ah (middle Pleistocene)** [E1, E2, F1, F2]

bya — **Basalt of Yalla (middle Pleistocene)** [D2]

oq4 — **Benmoreite of Gura 4 (middle Pleistocene)** [E2]

tz1 — **Trachyte of Um Znabah 1 (middle Pleistocene)** [E2]

Eruptive Stage 8 (323 to 360 ka)

bjab — **Basalt of Jabal (middle Pleistocene)** [D1]

blsa — **Basalt of Lower Sahab (middle Pleistocene)** [A1, A2]

bmu — **Basalt of Al Mustarah (middle Pleistocene)** [A1, B1]

bsj — **Basalt south of Al Jufdirah (middle Pleistocene)** [F2]

bsm — **Basalt of Sha'ib Murayyikh (middle Pleistocene)** [D1, D2, E1, E2]

Eruptive Stage 9 (360 to 460 ka)

baaj — **Basalt of Abar Al Julud (middle Pleistocene)** [D1, E1]

baq — **Basalt of Al Qurdi (middle Pleistocene)** [E1]

basu — **Basalt of As Sumak (middle Pleistocene)** [E2, F2]

bay — **Basalt of Atiyah (middle Pleistocene)** [C2]

bdg — **Basalt of Duwayghir (middle Pleistocene)** [E2, F2]

bduw — **Basalt of Ad Duwayfi'ah (middle Pleistocene)** [D1]

bhf7 — **Basalt of Hill 870 (middle Pleistocene)** [D1]

bhg — **Basalt of Al Harrah Al Gharbiyah (middle Pleistocene)** [A1]

bju — **Basalt of Al Jurb (middle Pleistocene)** [F1]

bmuf — **Basalt of Al Mufayriq (middle Pleistocene)** [F1, F2]

bmus — **Basalt of Muslimah (middle Pleistocene)** [F2]

bnh — **Basalt of Al Negea'ah (middle Pleistocene)** [F2]

bni — **Basalt north of Iskabah (middle Pleistocene)** [C2]

bnj — **Basalt north of Al Jufdirah (middle Pleistocene)** [F2]

bpr — **Basalt of Powerline Road (middle Pleistocene)** [A1]

bqi — **Basalt of Al Qiraxy (middle Pleistocene)** [E2, F2]

bqr — **Basalt of Quraydah (middle Pleistocene)** [A1, B1]

brb — **Basalt of Rawd Al Baham (middle Pleistocene)** [E1, F1]

brh — **Basalt of Rahat (middle Pleistocene)** [B1]

bri — **Basalt of Ar Ritajah (middle Pleistocene)** [E1, F1]

brum — **Basalt of Ar Rumahiyah (middle Pleistocene)** [F1]

brw — **Basalt of Ruwawah (middle Pleistocene)** [E1]

bsah — **Basalt of Shi'ban Al Hulayswat (middle Pleistocene)** [F2]

bsam — **Basalt of Sha'ib Al Maqrin (middle Pleistocene)** [D1, E1]

bsaw — **Basalt of Sha'ib Al Wuqayt (middle Pleistocene)** [E1]

bsou — **Basalt of Southwest (middle Pleistocene)** [F2]

bswu — **Basalt of Sha'ib Al Wuqayyit (middle Pleistocene)** [E1, F1]

bte — **Basalt of Abu Tunaydibah East (middle Pleistocene)** [C1, D1]

buh — **Basalt of Umm Hamd (middle Pleistocene)** [D2]

buj — **Basalt of Umm Ja'adat (middle Pleistocene)** [E2]

bur — **Basalt of Al Urayd (middle Pleistocene)** [A1]

burr — **Basalt of Upper Abu Rimthah (middle Pleistocene)** [C2, D2]

busa — **Basalt of Al Ushayrah (middle or early Pleistocene)** [F1]

busq — **Basalt of Usquf (middle or early Pleistocene)** [F1]

hsb — **Hawaiite of As Sabah (middle Pleistocene)** [D2]

mha — **Mugearite of Al Harara (middle Pleistocene)** [E2, F2]

mns — **Mugearite northwest of Al Shathaa (middle Pleistocene)** [D2]

mnzy — **Mugearite north of As Zayinah (middle Pleistocene)** [E2, F2]

msi — **Mugearite of Sha'ib Abu Sidrah (middle Pleistocene)** [E2]

msr — **Mugearite of Sha'ib Rushayyah (middle Pleistocene)** [D2, E2]

muq — **Mugearite of Umm Qurah (middle Pleistocene)** [D2, E2]

mz3 — **Mugearite of Um Znabah 3 (middle Pleistocene)** [E2]

mz6 — **Mugearite of Um Znabah 6 (middle Pleistocene)** [E2, F2]

mzy — **Mugearite of As Zayinah (middle Pleistocene)** [E2, F2]

oju — **Benmoreite of Um Junb (middle Pleistocene)** [D2]

osa — **Benmoreite of Al Shathaa (middle Pleistocene)** [D2, E2]

oz4 — **Benmoreite of Um Znabah 4 (middle Pleistocene)** [E2]

oz5 — **Benmoreite of Um Znabah 5 (middle Pleistocene)** [E2]

ozy — **Benmoreite of As Zayinah (middle Pleistocene)** [E2, F2]

tqa — **Trachyte of Al Qayf (middle Pleistocene)** [E2]

tz6 — **Trachyte of Um Znabah 6 (middle Pleistocene)** [E2, F2]

Eruptive Stage 10 (460 to 570 ka)

bada — **Basalt of Ad Dayyir (middle Pleistocene)** [D1]

bal — **Basalt of Al Ihn (middle Pleistocene)** [A1, B1]

bara — **Basalt of Ar Ra (middle Pleistocene)** [F2]

bbsh — **Basalt below Ash Shamali (middle Pleistocene)** [D1]

bedh — **Basalt east of Dab Al Harus (middle Pleistocene)** [D1, E1]

bef — **Basalt of Al Efairia (middle Pleistocene)** [D2, E2]

bfa — **Basalt of Al Farash (middle Pleistocene)** [D1]

bh82 — **Basalt of Hill 821 (middle Pleistocene)** [A1, A2]

bh83 — **Basalt of Hill 838 (middle Pleistocene)** [D1]

bha — **Basalt of Hathm (middle Pleistocene)** [A1]

bhc — **Basalt of Half Cone (middle Pleistocene)** [C1]

bhin — **Basalt of Al Hinu (middle Pleistocene)** [F2]

bhq — **Basalt of Sha'ib Huqif (middle Pleistocene)** [E1]

bis — **Basalt of Al Iskan (middle Pleistocene)** [A1]

bjg — **Basalt of Al Jaga (middle Pleistocene)** [C2]

bjn — **Basalt of Al Jan (middle Pleistocene)** [D2, E2]

bkf — **Basalt of Al Khafaq (middle Pleistocene)** [C1]

bmg — **Basalt of Al Mughatiyah (middle Pleistocene)** [C1]

bmh — **Basalt of Al Muq'iyah (middle Pleistocene)** [E1]

bmsm — **Basalt of Al Musamma (middle Pleistocene)** [E1]

bqu — **Basalt of Quba (middle Pleistocene)** [A1, B1]

brag — **Basalt of Ar Raghibah (middle Pleistocene)** [D1]

brg — **Basalt of Um Rgaibah (middle Pleistocene)** [E2]

bss — **Basalt of Sha'ib Si'ayd (middle Pleistocene)** [D1, D2]

btw — **Basalt of Abu Tunaydibah West (middle Pleistocene)** [D1]

buph — **Basalt of Upper Sha'ib Huqif (middle Pleistocene)** [E1, E2]

busm — **Basalt of Upper Sha'ib Murayyikh (middle Pleistocene)** [D2]

bwhu — **Basalt west of Al Hurus (middle Pleistocene)** [D1, D2]

byid — **Basalt of Yidum (middle Pleistocene)** [F2]

bzi — **Basalt of Az Zinitah (middle Pleistocene)** [C1, D1]

hhil — **Hawaiite of Hilayyat (middle Pleistocene)** [E2, F2]

og3 — **Benmoreite of Gura 3 (middle Pleistocene)** [D2]

oeb — **Benmoreite of As Sabah (middle Pleistocene)** [D2]

Eruptive Stage 11 (570 to 780 ka)

bas — **Basalt of Abu Sidrah (middle Pleistocene)** [E2]

bat — **Basalt of Atiq (middle Pleistocene)** [D1, D2, E1, E2]

bba — **Basalt of Al Bayadah (middle Pleistocene)** [D2]

bd1 — **Basalt of Dabaa 1 (middle Pleistocene)** [D2]

bg1 — **Basalt of Gura 1 (middle Pleistocene)** [D2]

bja — **Basalt of Al Jar'ah (middle Pleistocene)** [E1]

bmy — **Basalt of Al Matyan (middle Pleistocene)** [E1, E2]

bsd — **Basalt of Sha'ib Ad Dirwah (middle Pleistocene)** [E2]

bsl — **Basalt of Sha'ib Luwa (middle Pleistocene)** [A1, A2]

bsw — **Basalt of Umm Suwasi (middle Pleistocene)** [E1, E2]

buq — **Basalt of Umm Qubayr (middle Pleistocene)** [E2]

bush — **Basalt of Al Ushu'a (middle Pleistocene)** [E2]

msa — **Mugearite southwest of Al Shathaa (middle Pleistocene)** [D2, E2]

Eruptive Stage 12 (780 to 1,200 ka)

bg3 — **Basalt of Gura 3 (early Pleistocene)** [D2]

bgh — **Basalt of Ghadwar (early Pleistocene)** [E1, E2, F1, F2]

bgo — **Basalt of Gorab (early Pleistocene)** [E2]

bh89 — **Basalt of Hill 892 (early Pleistocene)** [B1, C1]

bqa — **Basalt of Al Qafif (early Pleistocene)** [F2]

burq — **Basalt of Upper Qa Al Aqul (early Pleistocene)** [A1]

VOLCANIC ROCKS OF HARRAT KURAMA

Qbhk — **Basalt of Harrat Kurama (early Pleistocene)** [A2]

Qbjs — **Basalt of Jabal Umm Suhaylah (early Pleistocene)** [A1]

Qbra — **Basalt of Ar Ramram (early Pleistocene)** [A1]

TERTIARY VOLCANIC ROCKS

Tbja — **Basalt of Jabal Ayr (Miocene)** [B1]

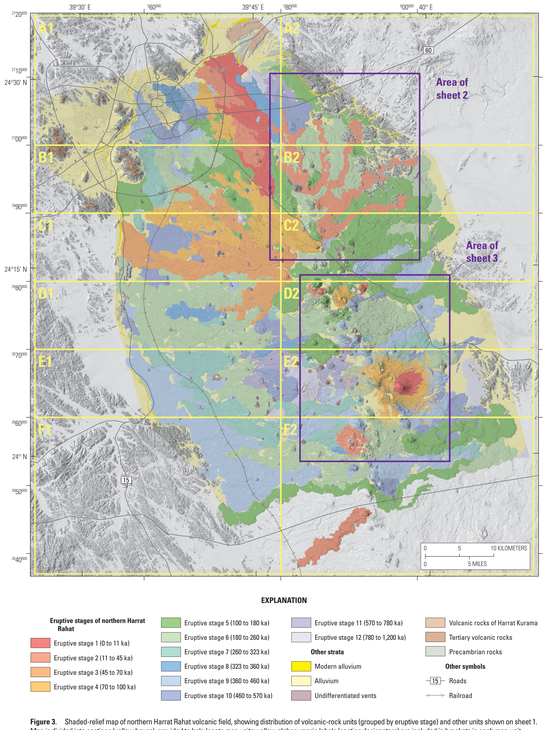
Tbj — **Basalt of Jabal Jammah (Miocene)** [A1, B1]

PRECAMBRIAN ROCKS

pC — **Precambrian rocks (Precambrian)** [A1, A2, B1, B2, C1, C2, D1, D2, E1, E2, F1]

EXPLANATION OF MAP SYMBOLS

- **Contact**—Solid where location is accurate; long-dashed where location is approximate; short-dashed where location is inferred. Internal contacts delineate individual vents
- **Cryptodome boundary**—May coincide with contact between mapped units
- **Fault**—Accurately located. Bar and ball on downdropped block
- **Ground cracks**
- **Graben trace**
- **Eruptive vent, crater, dome, and cryptodome**
- **Ends of section boundaries**
  - A | B — East-west
  - 1 | 2 — North-south
- **Road**
- **Railroad**
- **Boundary between unmapped Harrat Rahat and other unmapped strata**



EXPLANATION

Eruptive stages of northern Harrat Rahat
- Eruptive stage 1 (0 to 11 ka)
- Eruptive stage 2 (11 to 45 ka)
- Eruptive stage 3 (45 to 70 ka)
- Eruptive stage 4 (70 to 100 ka)
- Eruptive stage 5 (100 to 180 ka)
- Eruptive stage 6 (180 to 260 ka)
- Eruptive stage 7 (260 to 323 ka)
- Eruptive stage 8 (323 to 360 ka)
- Eruptive stage 9 (360 to 460 ka)
- Eruptive stage 10 (460 to 570 ka)
- Eruptive stage 11 (570 to 780 ka)
- Eruptive stage 12 (780 to 1,200 ka)

Other strata
- Modern alluvium
- Alluvium
- Undifferentiated vents
- Volcanic rocks of Harrat Kurama
- Tertiary volcanic rocks
- Precambrian rocks

Other symbols
- Roads
- Railroad

Figure 3. Shaded-relief map of northern Harrat Rahat volcanic field, showing distribution of volcanic-rock units (grouped by eruptive stage) and other units shown on sheet 1. Map is divided into sections (yellow boxes), provided to help locate map units; yellow alphanumeric labels (section designators) are included in brackets in each map-unit description (see Description of Map Units, in pamphlet; see also, List of Map Units and column heads in Correlation of Map Units). Also shown are areas of 1:25,000-scale maps on sheets 2 and 3. Shaded-relief base map from 12-m-resolution TanDEM-X digital elevation model acquired from German Aerospace Center in 2017. Roads and railroad modified from OpenStreetMap data in 2015.

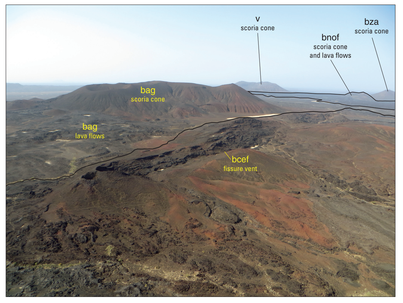


Figure 8. Photograph to west-northwest, showing 1.9-km-long fissure vent that erupted the basalt of Central Finger (unit bcef, 24.4±1.3 ka; sections A2, B2). Also identified are lava flows and scoria cones of several nearby units. Photograph by Hannah Dietterich, 2016.

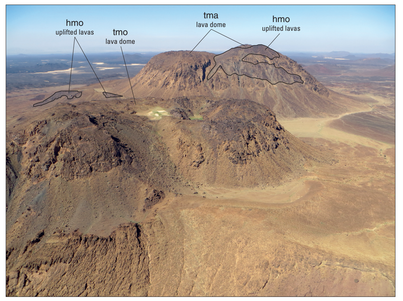


Figure 9. Photograph to north-northwest, showing domes of the trachyte of Mouteen (unit tmo, 31.9±2.1 ka; section D2) and the trachyte of Matan (unit tma, 121.5±1.4 ka; sections C2, D2). Each high-standing lava dome has small central craters and apron of pyroclastic-flow deposits that overlie basalt and mugearite lava flows. Also identified are uplifted lava flows of the hawaiite of Mouteen (unit hmo, 239.0±4.1 ka). Photograph by Hannah Dietterich, 2016.

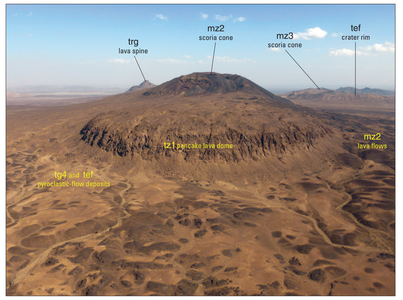


Figure 10. Photograph to southeast, showing pancake lava dome of the trachyte of Um Znabah 1 (unit tz1, 268.1±5.0 ka; section E2). Behind it is high-standing scoria cone, vent for the mugearite of Um Znabah 2 (unit mz2, 195.8±1.3 ka; sections D2, E2). To left of scoria cone (unit mz2) is lava spine of the trachyte of Um Rgaibah (unit trg, 4.2±5.2 ka; section E2). Also identified are lava flows, pyroclastic-flow deposits, crater rim, and scoria cone of several nearby units. Photograph by Andrew Calvert, 2014.

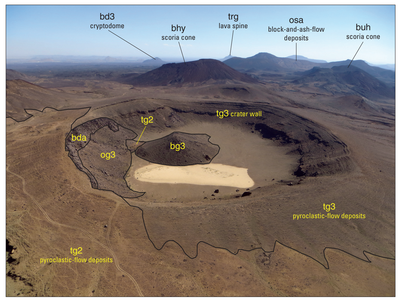


Figure 11. Photograph to southeast, showing crater that formed during eruption of the trachyte of Gura 3 (unit tg3, 142.4±2.2 ka; section D2). Remnant of the basalt of Gura 3 (unit bg3, 1,112.1±17.6 ka; section D2) is exposed on crater floor; visible in crater wall are the benmoreite of Gura 3 (unit og3, 558.7±4.8 ka; section D2) and the basalt of Ad Darah (unit bda, 223.0±18.9 ka; section D2). Also identified are cryptodome, lava spine, block-and-ash-flow deposits, pyroclastic-flow deposits, and scoria cones of several nearby units. Light-yellowish-tan sediment within unit tg3 on crater floor is alluvium (unit Qal). Photograph by Hannah Dietterich, 2016.

Correlation and List of Map Units for the Geologic Map of the Northern Harrat Rahat Volcanic Field, Kingdom of Saudi Arabia

By

Drew T. Downs,[1] Joel E. Robinson,[1] Mark E. Stelten,[1] Duane E. Champion,[1] Hannah R. Dietterich,[1] Thomas W. Sisson,[1] Hani Zahran,[2] Khalid Hassan,[2] and Jamal Shawali[2]

2019

[1]U.S. Geological Survey;
[2]Saudi Geological Survey

Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government.

This map or plate also is offered in an online, digital version. Users should be aware that, because of differences in rendering processes and pixel resolution, some slight distortion of scale may occur when viewing the online version on a computer screen or when printing it on an electronic plotter, even when it is viewed or printed at its intended publication scale.

For sale by U.S. Geological Survey, Information Services, Box 25286, Federal Center, Denver, CO 80225, 1–888–ASK–USGS

Digital files available at https://doi.org/10.3133/sim3428 and https://doi.org/10.5066/P9ZSNS7N

Suggested citation: Downs, D.T., Robinson, J.E., Stelten, M.E., Champion, D.E., Dietterich, H.R., Sisson, T.W., Zahran, H., Hassan, K., and Shawali, J., 2019, Correlation and List of Map Units for the geologic map of the northern Harrat Rahat volcanic field, Kingdom of Saudi Arabia, sheet 4 in Geologic map of the northern Harrat Rahat volcanic field, Kingdom of Saudi Arabia: U.S. Geological Survey Scientific Investigations Map 3428 (also released as Saudi Geological Survey Special Report SGS–SP–2019–2), 65 p., 4 sheets, scales 1:75,000, 1:25,000, https://doi.org/10.3133/sim3428.

Associated data for this publication: Robinson, J.E., Downs, D.T., Stelten, M.E., Champion, D.E., Dietterich, H.R., Sisson, T.W., Zahran, H., Hassan, K., and Shawali, J., 2019, Database for the geologic map of northern Harrat Rahat volcanic field, Kingdom of Saudi Arabia: U.S. Geological Survey data release, https://doi.org/10.5066/P9ZSNS7N.

Printed on recycled paper

ISSN 2329-1311 (print)
ISSN 2329-132X (online)
https://doi.org/10.3133/sim3428