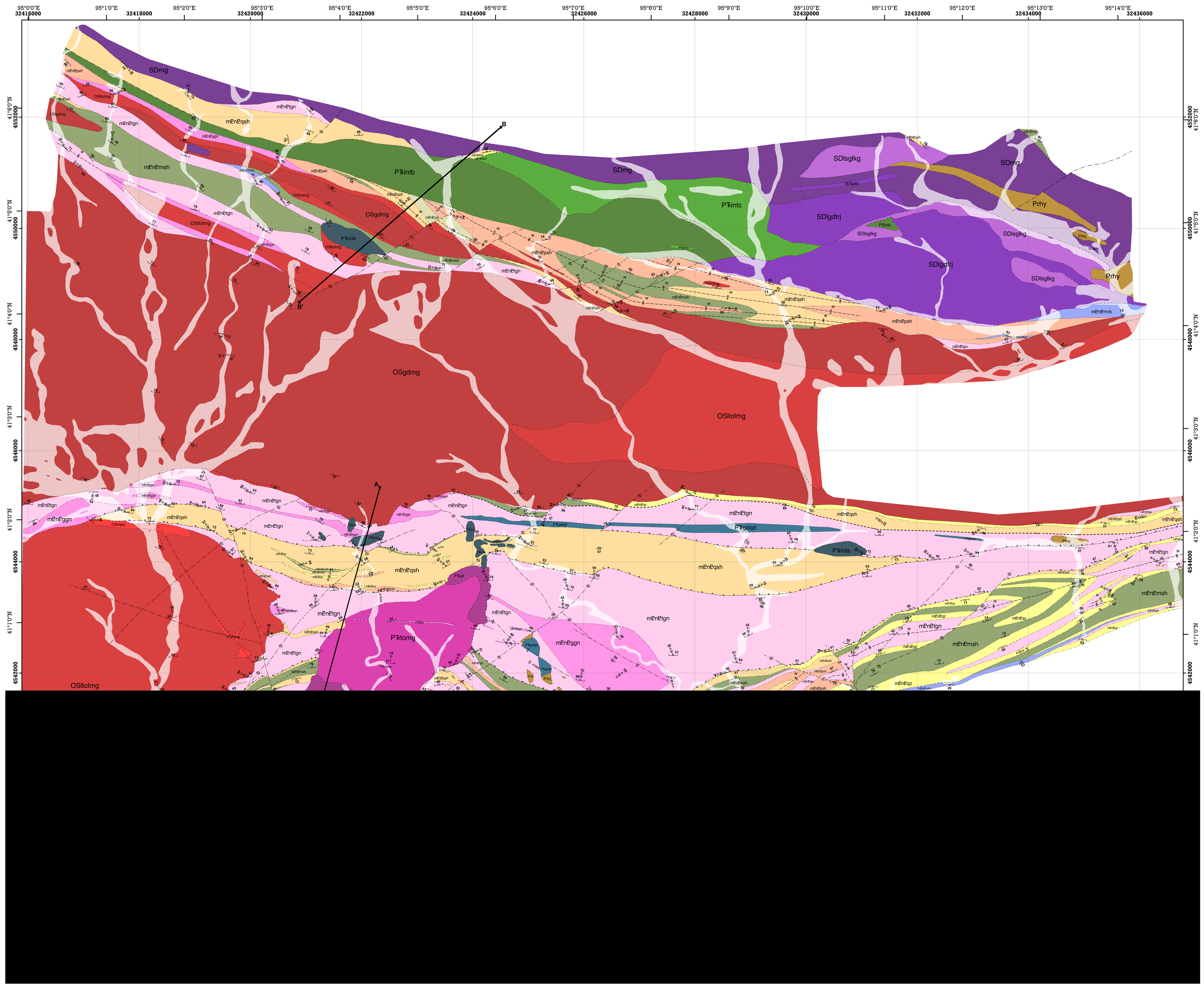
Map of study area



Description

Introduction and rationale for investigation

The study area is situated in the Beishan Orogenic Collage and includes the Ordovician Gubaoquan eclogite. It is primarily composed of Meso- to Neoproterozoic igneous and sedimentary rocks, which underwent penetrative deformation and metamorphism to eclogite-facies conditions during the late Ordovician, early Silurian. During the same period, several major granitoids were emplaced into this metamorphic tectonite belt Whilst the area bears evidence for a major orogenic event, the structure of the metamorphic tectonites is thoroughly understudied, and the relation of the structures to metamorphism and igneous activity is poorly understood. The majority of the tectonite belt now bears amphibolite-facies fabrics, which obliterated nearly all eclogite-facies assemblages. As a consequence, little constraints exist on the tectonic processes responsible for the uplift and exhumation of the eclogite. The area was mapped at 1:25.000 scale during two field seasons in 2018 and 2019. Previous mapping was conducted at a 1:50.000 scale, by the Gansu Bureau of Geology and Mineral Exploration and Development.

Geological units

The rocks of the Gubaoquan area were divided into numerous lithological units. These can broadly be divided into six different groupings, based on their age: a Palaeozoic belt of highly deformed metamorphic tectonites; three largely undeformed granitoids, one of Ordovician-Silurian age, one of Devonian age and one presumably of Carboniferous-Permian age; a cover comprised of Permian rhyolites and conglomerates; mafic dykes, presumably of Permian age. The mafic dykes and conglomerate are too small to feature on this map. In addition, the area hosts a multitude of smaller Permian-Triassic felsic-mafic intrusions.

Metamorphic tectonites

The metamorphic tectonites consist of intercalated layers and lenses of orthogneiss, mafic schist and metasedimentary rocks. These can be sub-divided into two domain types: one primarily composed of metasedimentary rocks and metabasites, and one with primarily metabasites and orthogneiss. When felsic orthogneiss does occur within the latter, these usually occur in close association with metabasites and trondhjemites and are not megacrystic. If not obscured by younger intrusions, domain boundaries usually constitute shear zones.

The protoliths of the metasedimentary rocks were intruded by mafic dykes (mꝐnꝐmsh), which together with their host were metamorphosed to (garnet) amphibolite. Some form continuous, hundred-metre-thick packages, whilst in other instances, these can form metre-thick lenses within the metasedimentary rocks. The amphibolites often are associated with significant bodies of metatrondhjemite and -tonalite. These are never megacrystic and usually do not show augen textures, in contrast to the felsic augen gneisses found elsewhere. Soldner et al (2019) obtained a lower age cluster of 910.9±3.0 Ma and an upper one at 1378±15 Ma for an amphibolite adjacent to the eclogite. There is a possibility that the metabasites are composed of several suites of protoliths.

The orthogneiss intrudes all of the above units. They primarily have granitic (mꝐnꝐggn) to tonalitic (mꝐnꝐtgn) compositions and often are leucocratic. Some of the orthogneisses are megacrystic, with ≤15 cm feldspathic augen, whereas in other areas extensive shearing has completely recrystallised these or rocks bearing smaller equivalents into mylonites. An igneous U-Pb zircon age of 920±14 Ma has been interpreted as the protolith′s emplacement age (Saktura et al, 2017). This age was obtained from a tonalite gneiss immediately south of the eclogite. An age of 867.5±1.9 Ma was obtained at another orthogneiss, close to the eclogite (Soldner et al, 2019).

The eclogite (nꝐecl) is hosted within domain I and consists of one major and several smaller variably retrogressed, foliation-parallel screens. Towards the west of the major lens, the eclogite and its enveloping host are truncated by a Silurian granitoid body. Towards the east, a trail of smaller lenses can be traced up to the southern boundary of the tectonite belt. Eclogitic-facies assemblages are prevalently preserved in the cores of lenses; the edges have usually been retrogressed to amphibolite, with a few smaller lenses having retrogressed completely. Abundant garnet within a green matrix occurs within the least retrogressed parts. In thin section, the latter was found to primarily consist of cpx-plg symplectites that pseudomorph omphacite. Zircons (U-Pb) from the eclogite yielded 875-860 Ma for the cores, 465-460 Ma for the rims.

Ordovician - Silurian granitoid intrusions

Two major granitoids are part of this stage. The one in the south primarily consist of hornblende-biotite-titanite monzogranite, granodiorite and tonalite (OSltolmg), whilst the one in the north also has a less leucocratic unit that compositionally is a granodiorite to syenogranite (OSgdmg, OSmgsg). Both intrusions also bear abundant dykes of gabbro, microdiorite (OSgb), leucogranite and trondhjemite (OStrj). The south-western intrusion was dated at 442±4 Ma with zircon U-Pb (Mao, 2008), whilst the middle one has ages of 442±3 (Mao, 2008) and 424±3 Ma (Mao et al, 2012).

Silurian - Devonian granitoid intrusions

The north of the mapping area is bound by a major batholith that primarily consists of monzogranites with <5 cm alkali feldspar megacrysts (SDmg). Several smaller-grained bodies of leucosyenogranite to leuco-Kfs-granite (SDlsglkg) and leucogranodiorite to trondhjemite (SDlgdtrj) occur immediately south of it. A megacrystic granite and syenogranite both yielded Devonian ages of 404.4±1.8 Ma and 418.5±4.4 Ma, respectively and have been interpreted as arc granitoids (Zhu et al, 2016).

Permian rhyolites and conglomerate

In a very small area, undeformed conglomerates occur. These are intruded by flow-banded rhyolites (Prhy), which also occur in the north-east of the area. The flow bands are internally folded into an irregular geometry, suggesting these are igneous flow textures. The conglomerate (too small to feature on map) has clasts of pure quartz, pure feldspar, gneiss, dolerite and granite. Unfortunately, the contact appears to have been structurally modified, but most likely these represent basal conglomerates. The conglomerate has not been described before but may be correlatable to sedimentary units that non-conformably overly the gneisses towards the east (Li et al, 2019). The same study also describes several similarly aged (282.2±2.1 Ma) rhyolites in the north-east.

Permian-Triassic granitoid intrusion

This concerns one major intrusion located to the south-east of the Ordovician-Silurian intrusions. The primary unit is PꞦtomg, a biotite-hornblende tonalite to monzogranite. This unit locally grades into PꞦmgsg, a biotite-hornblende monzogranite to syenogranite. It is bordered by PꞦqd, a biotite-hornblende(-clinopyroxene) quartz-diorite, with which the intrusion relationship currently is unclear. A leucocratic tonalitic dyke (PꞦlto) crosscuts PꞦtomg. This intrusion crosscuts Permian D6 faults and therefore is younger. No radiometric ages have been obtained on this intrusion.

Permian-Triassic mafic dykes

Many gabbroic (PꞦinta) and doleritic dykes (too small to feature on map) crosscut the area. These range in size from a few centimetres to several metres. An extraordinary number of dykes is found in the south-west of the study area, where one can find anastomosing systems of one-two metre-wide doleritic dykes. Generally, these dykes trend NE-SW. The sharp, straight contacts with the country rock and absence of baked margins are indicative of relatively rapid cooling. The dolerites are sufficiently medium-grained and are consistently composed of clinopyroxene, plagioclase and a substantial volume of opaque minerals. The gabbros are similar in composition but coarser-grained. Many also contain chlorite, indicating low-temperature alteration. These dykes have a maximum age of 282±6 Ma, based on the youngest xenocrystic zircon present (Zhang et al, 2015).

Minor Permian-Triassic mafic-intermediate intrusions

This comprises several smaller intrusions. As they occur across a large area, the exact crosscutting relationships between them commonly have not been constrained. PꞦgdqd is a km-long dyke of granodiorite, quartz-diorite and tonalite. Units PꞦintb and PꞦintc concern a complicated zone of felsic-mafic intrusions situated just south of the Devonian granitoid. PꞦintc primarily consists of rhyolite and leucogranite, with minor medium-grained granodiorite, (quartz-monzo)diorite and syenite. Characteristic are their Ꝑ1cm alkali feldspar phenocrysts. The rhyolites are also found to bear chloritised mica and/or plagioclase phenocrysts. PꞦintb consists of andesites, dacites, dolerites, micro-diorites and rhyolites. These variably have plagioclase, quartz, chlorite, hornblende and/or alkali feldspar phenocrysts. Lastly, unit PꞦgdqd concerns dolerite, diorite and gabbro, which occasionally have undergone greenschist-facies metamorphism. Unit PꞦgdqd appears coeval to D6 and probably is older than the Permian-Triassic intrusion. All other units crosscut D6 faults and therefore are younger. No radiometric ages have been obtained on any of these intrusions as of yet.

Structural architecture

The area underwent a complicated structural history. In total, six to seven generations were identified, based upon overprinting relationships orientation and/or metamorphic assemblage. D1-D3 have only been observed in the metamorphic tectonite belt, as they predate the emplacement or depositional age of the succeeding units. D1 fabrics have only been preserved as internal foliations in porphyroblasts, whilst S2 has only been preserved in fold hinges. Everywhere else, S2 has been transposed into S3. S3 commonly occurs in highly strained rocks and most of the area′s shear zones were probably active during D3. Due to extensive refolding, S3 strikes and L3 plunges variably. In units mꝐnꝐtgn and mꝐnꝐggn, S3 comprises gneissic and mylonitic textures, in the metasedimentary units comprises a schistosity or mylonitic texture. L3 consists of preferential mineral alignment and mineral / augen stretching lineations. F3 folds S2 and compositional layering and comprises tight to isoclinal, noncylindrical and asymmetrical.

D4 is observed in the metamorphic tectonite belt, whereas the Ordovician-Silurian intrusions frequently bear a foliation that is (sub)coeval to D4. Whilst one shear zone was folded by F4, others may have been active during D4. In the metamorphic tectonite belt, S4 is a crenulation cleavage to S3, which is regularly observed in F4 hinge areas. In Ordovician-Silurian igneous units, S4 consists of preferential mineral alignment. F4 folds are open to tight, noncylindrical and have steep, north-inclined, E-W-striking axial planes and E-W trending hinge lines.

D5 structures primarily occur in the Liuyuan ophiolite and within bordering areas of the metamorphic tectonite belt. S5 occurs as shallowly dipping, S-directed shear zones, which do not appear to be associated with very large degrees of displacement. F5 constitutes asymmetrical drag folds with broadly NE-dipping, variably dipping axial planes and shallowly plunging, NE-directed hinge lines.

D6 faults crosscut nearly every unit, except the Permian-Triassic units mentioned in the lithology section. No S6 or L6 has been observed. In unit mꝐnꝐqsh, F6 comprises box folds with N-S-striking, sub-vertical axial planes and moderately N-plunging hinge lines. In other units, F6 consists of open, upright folds or crenulations with comparable axial plane orientations as the box folds, but variably N-S plunging hinge lines. These folds are particularly prominent near the southern boundary of the metamorphic belt and near major brittle faults.

D7 which comprises refolded D6 folds, have only been observed at a few localities in the metamorphic tectonite belt. D7 folds are recumbent, have moderately NW-SE striking axial planes and variably NW-plunging hinge lines. D6 has not been associated with any meso-scale structures.

Metamorphism

Metamorphism is consistently of amphibolite-grade throughout the metamorphic tectonite belt, with eclogite-facies conditions preserved in the small mafic boudins. In younger units, metamorphism is restricted to the vicinity of faults and shear zones, where greenschist-facies assemblages can be observed. In the metamorphic tectonites, multiple high-grade fabrics are preserved. M1 has only been preserved as folded inclusion trails in garnet and kyanite in meta-pelitic assemblages, which have not been studied yet. This fabric may be broadly coeval with the peak assemblage in the eclogites. M2 has only been preserved in fold hinges and as inclusions trails in kyanite. S2 is associated with biotite, muscovite and quartz in unit mꝐnꝐpsh, whilst kyanite has a syn- to post-kinematic relationship to S2. Overall, D2 is associated with amphibolite-facies conditions. In unit mꝐnꝐpsh, S3 primarily consists of quartz, biotite and muscovite. Both staurolite and andalusite have inter- to syn-tectonic relationships to S3. In unit mꝐnꝐpsh, S3 predominantly consists of garnet, hornblende, quartz and plagioclase. These assemblages broadly represent garnet amphibolite-facies conditions. Whilst D4 fabrics are widespread, D4 & D5 metamorphic assemblages have only been sporadically observed in thin section. In unit mꝐnꝐqsh, S4 consists of muscovite and quartz, reflecting greenschist- to amphibolite-facies conditions. In unit mꝐnꝐmsh, S5 is associated with chlorite and occasionally epidote and/or actinolite, representing greenschist-facies conditions.

Geochronology

Early garnet growth, interpreted as having started during prograde metamorphism, is thought to have been dated with garnet-whole rock-clinopyroxene Lu-Hf isochrones at ~461 Ma (Soldner et al, 2020). Sm-Nd isochrones yielded ages of ~453 Ma, which have been interpreted as peak-metamoprhism (Soldner et al, 2020). D1 fabrics are thought to have formed approximately at this time. No clear age is available for D2, but based on the preceding and succeeding deformation ages, it would have occurred between ~453 and ~440 Ma. U-Pb dating of monazite cores in a metagreywacke, thought to have grown approximately at the time of D3 deformation, yielded ~445-440 Ma (Soldner et al, 2020). Based on the ~442-424 Ma U-Pb zircon ages of syn-tectonic granites and granodiorites (Mao et al, 2008; Mao et al, 2012), U-Pb zircon rim ages of ~436 on a retrograde eclogite (this study) and U-Pb monazite ages of ~436-429 from a metagreywacke (Soldner et al, 2020), D4 deformation is approximately 424 to 442 Ma. As D5 fabrics are found in both the metamorphic tectonite belt and the Permian Liuyuan ophiolite, D5 deformation has to be younger than ~286 Ma (Mao et al, 2012b). As D6 faults crosscut the Liuyuan ophiolite, the same applies to D6 and D7 deformation.

Tectonic setting

The metamorphic tectonite belt represents Meso- Neoproterozoic crust that underwent Ordovician-Silurian continental subduction to various depths and collision-related tectonism, including detachment from the down-going slab and incorporation into an orogenic wedge. Continental subduction possibly continued until the emplacement of the syn-tectonic Ordovician-Silurian arc granitoids, which could be related to slab break-off. The Silurian-Devonian granitoid was emplaced shortly after this, but its tectonic setting currently is unknown. Most of the area was eventually partially exhumed in the Permian-Carboniferous, marked by the deposition of a basal conglomerate and (sub-)volcanic rhyolites. D5-D7 deformation most likely relates to Carboniferous-Permian convergence and the obduction of the Liuyuan ophiolite, driven by subduction in oceanic domains existing to the south at that time (Mao et al, 2012).

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Lithology

Triassic to Permian

PꞦintc — Undifferentiated felsic intrusions. Complicated unit that predominantly consists of rhyolite and minor occurrences of microgranodiorite, micro-(quartz-monzo)diorite and syenite. Area also has many occurrences of SDlsglkg but these are undifferentiable at this scale. Characteristic are their ≤1cm alkali feldspar phenocrysts, found in all units. The rhyolites are also found to bear chloritised mica and/or plagioclase phenocrysts. The rhyolites intrude into SDlsglkg and PꞦintb. Not offset by D6.

PꞦintb — Undifferentiated mafic-felsic (sub)volcanic intrusions. Includes andesites, dacites, dolerites, micro-diorites and occasionally rhyolites, which are undifferentiable at this scale. Aphanitic to fine-grained, phenocrytic. Variably have plagioclase, quartz, chlorite, hornblende and/or alkali feldspar phenocrysts. Has xenoliths of and intrudes into the SDlsglkg. Not offset by D6.

PꞦinta — Undifferentiated mafic-intermediate intrusions. Includes several suites, which are not necessarily related. Lithologies include dolerite, gabbro and minor diorite. Usually dark grey to dark blue in colour. Notably, this unit may contain a substantial volume of opaque minerals. Some intrusions contain chlorite, indicating greenschist-facies metamorphism. Generally, the intrusions have a sharp contact with the country rock, no baked or chilled margins. In addition to the intrusions marked on the map, these units occur as one-two-metre-wide, NW-SW-trending dykes. These are too small to mark on the map but are most common in the south-west of the study area. Intrudes into SDgdmg, PꞦtomg and crosscuts D6 faults. Too geographically distant from PꞦintb and PꞦintc to assess their temporal relationship.

PꞦlto — Leucocratic tonalite. Light grey. ≤2mm crystals, euhedral and equigranular. Often sericitised and chloritised. Has a slight preferential mineral alignment in places. Intrudes PꞦtomg.

PꞦmgsg / PꞦtomg — Tonalite to syenogranite. Creamy white to light pink in colour. Generally coarse- to medium-grained and subequigranular. Occasionally leucocratic. Variably has phlogopite and/or hornblende as mafic phases, which usually are phenocrytic. Commonly granodioritic in composition, locally grading into tonalite or monzogranite (PꞦtomg). A few distinct areas have syenogranitic to monzogranitic compositions (PꞦmgsg), but the contact between PꞦmgsg and PꞦtomg has not been observed in outcrop. Crosscuts D6 faults.

PꞦqd — Quartz-diorite. Dark grey, with hornblende, phlogopite and occasionally clinopyroxene as mafic phases. Plagioclase grows interstitially. Usually equigranular with ≤1mm crystals, but occasionally contains ≤1cm hornblende phenocrysts. Unfoliated. Borders PꞦtomg, but contact has not been observed in outcrop - intrusive relationship is currently unclear

PꞦgdqd — Granodiorite to quartz-diorite. Grey-blue, diabasic texture, usually medium-grained. Includes granodiorite, tonalite and quartz diorite. Sometimes has a weakly developed fracture cleavage. Both offset and crosscut by D6 faults, suggesting they are (sub)-coeval. Intrudes into Prhy, contains mꝐnꝐqz and mꝐnꝐtgn xenoliths.

Permian

Prhy — Undifferentiated rhyolite. Includes several suites. Deep pink, light pink and light green in colour. Aphanitic, bears minimal mafic minerals. May contain phlogopite, quartz, (epidotised) plagioclase and/or pyrite phenocrysts. Phenocrysts commonly are ≤3 mm, occasionally ≤1 cm. Frequently has spherulitic textures (≤1 cm) and/or flow banding. Crosscuts several units, including SDmg. Offset by D6 faults.

Silurian to Devonian

Huitongshan and Shijinpo granites

SDlsglkg — Leucosyenogranite to leuco-alkali-feldspar-granite, light to dark pink. Coarse-grained (4-7 mm), variably subequigranular to unequigranular. A sharp contact exists between the two, but these are not differentiable at this scale. The syenogranite includes xenoliths of Kfs-granite. Occassionally contains (chloritised) muscovite or biotite. Intrudes SDmg.

SDlgdtrj — Leucogranodiorite to trondhjemite, pink-grey in appearance. Medium-grained (≤4mm), subequigranular. Usually a leucogranodiorite, but occasionally grading into trondhjemite. Occassionally contains hornblende and/or phlogopite. The latter has often been subjected to chloritisation. Feldspars have variably been sericitised as well. Intruded by SDlsglkg, intrudes SDmg.

SDmg — Megacrystic granite, unequigranular monzogranite with ≤5cm alkali feldspar megacrysts. Megacryst concentrations vary, from essentially zero to cumulate textures. Phlogopite and hornblende are the primary mafic phases. The phlogopite occasionally gets chloritised.

Ordovician to Silurian

OSgb — Gabbro to diorite, dark blue grey in colour, coarse, diabasic texture. Observed intruding as a composite dyke along with OSltolmg and has xenoliths of said unit. Elsewhere, it is found intruding as a composite dyke with OStrj, which it also crosscuts. Of some (micro)gabbroic intrusions, it is unclear whether these belong to this unit or PꞦinta.

OStrj — Trondhjemite to leucogranite, white to light pink. Coarse, occassionally pegmatitic. Dykes of this unit are very common throughout the area but are too small to display at this scale. Larger outcrops are commonly associated with D3-D4 fault/shear zones. May be lightly foliated. Crosscuts OSltolmg and PꞦinta.

OSmgsg / OSltolmg — Leucocratic tonalite to syenogranite light pink to white, coarse (≤4 mm) and unequigranular. Hornblende, phlogopite and titanite are the dominant mafic phases. Rarely contains muscovite. Compositionally a monzogranite, granodiorite and occasionally a tonalite (OSltolmg). These appear to grade into each other, no mappable contacts were observed. Furthermore, small areas grade into monzogranite to syenogranite (OSmgsg). Many of these occurrences are associated with D6 faults − potentially, these are the result of alteration. Occassionally lightly to strongly foliated (mineral alignment), particularly near the intrusion boundaries. Intrudes OSgdmg.

OSgdmg — Granodiorite to monzogranite, speckled black-white in appearance. Coarse, unequigranular and variable in grain size. Contains ≤1cm zoned plagioclase phenocrysts. Hornblende, titanite and phlogopite are the dominant mafic phases. Primarily granodioritic in composition, with some tonalitic sections. Many sections are strongly foliated to gneissic.

Mesoproterozoic to Neoproterozoic

nꝐecl — Eclogite and retrogressed equivalents. Occurs as ≤500m pods, of which the cores frequently eclogite-facies textures. Green-red in relatively fresh areas, dark blue-black in more retrogressed sections. Usually rather coarse (≤6mm). The least retrogressed areas predominantly consist of diopside-albite symplectites, garnet and rutile, whereas the most retrogressed areas consist of hornblende, plagioclase, quartz, biotite, and preserved remnants of higher-grade assemblages. Most likely had a basaltic or gabbroic protolith.

mꝐnꝐggn — Pink gneiss, white to pink. Can have ≤10 cm K-feldspar augen in the least strained parts, whereas in others these augen are smaller and/or were extensively stretched. Large cm-size quartz-plagioclase porphyroblasts are common, which sometimes bear euhedral hornblende inside. The interstitial areas primarily consist of biotite with quartz and plagioclase. Occasionally garnetiferous. Epidotisation and chloritisation is commonplace towards the south, whereas muscovitisation is frequently observed in highly strained areas. Usually bears a gneissic texture, less so in areas with small mafic components. Frequently mylonitic. Most likely had (leuco)granitic to granodioritic, occasionally Kfs-granitic protoliths.

mꝐnꝐtgn — Grey gneiss, white to light grey. May locally be pink, most likely due to potassic alteration. A yellow colour is common in lower-lying areas, most likely due to alteration. As with the pink gneisses, these can contain ≤10 cm plagioclase augen. Interstitial areas primarily consist of quartz, plagioclase, biotite and hornblende. Regularly, these rocks will also contain white mica, primarily in highly strained parts. Occasionally garnetiferous. Commonly, these rocks will bear a well-developed gneissic texture, less so in areas with small mafic components. Frequently mylonitic. Most likely had trondhjemitic, tonalitic, granodioritic or occasionally quartz-dioritic protoliths.

mꝐnꝐmsh — Mafic schist, black, often appears to be a hornblendite but generally contains ≥10% plagioclase. Can be very coarse (≤1cm) or fine (≥1mm), but usually 2-3mm crystal size. Primarily consists of dark brown to blue-green amphibole, sometimes with clinopyroxene or plagioclase needles. Frequently garnetiferous. Probably had (mela)gabbroic, (mela)dioritic, basaltic protoliths.

mꝐnꝐmrb — Marble, creamy white, light ochre or grey; pervasively foliated and sometimes intensely sheared; ranges from nearly pure marble to calc-arenite.

mꝐnꝐpsh — Metapelites, dark brown to grey-black; the schistosity is best developed in the most pelitic samples, owing to abundant biotite. Fairly coarse. Usually devoid of any indicator minerals that are visible to the eye but occasionally contains kyanite or garnet.

mꝐnꝐqsh — Quartz schist, Light grey to light brown; includes any meta-arenite but tends to be very quartz-rich (≥50%). Medium fine to coarse. Usually bears a cm-spaced pervasive foliation but lacks foliation in more quartzose occurrences. Generally devoid of any indicator minerals that are visible to the eye but contains garnet in some cases.

mꝐnꝐqz — Quartzite, White to light grey; massive to poorly foliate; nearly 100% quartz with only a small amount of brown or white mica; coarse and usually completely recrystallised, but some inherited grain shapes can be discerned in some cases

mꝐnꝐcgl — Metaconglomerate, relatively rare in the field and description is based on a small number of outcrops, predominantly in the very north of the mapping area. Light grey to light brown. Composed of variable quantities of ≤3cm mafic, calcite, feldspar, quartz or leucogranitic clasts, usually in a strongly foliated to mylonitic micaceous matrix.

Shaded are areas with no outcrop, extended areas of no outcrop are shown in white

Symbology

Lithological contacts (defined or approximate, inferred)......
Fault: thrust or reverse (defined or approximate, inferred)..
Fault: general (defined or approximate, inferred)...............
Fold axial trace, approximate (anticline, syncline, overturned anticline, overturned syncline)..........................
Fold axial plane (F3-F7)...
Fold hinge (F3-F7)..
Foliation (S2-S4, Sn+4)...
Lineation (L3, L4, Ln+4)..

Bedrock geology

Gubaoquan area

Gansu, China

Projection: CGCS2000 3 Degree GK Zone 32

1:25.000

Figure 27. 1:25.000 map of study area