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MICROSTRUCTURES OF SOME ALKALI-SILICA REACTIVE AGGREGATES IN CHINA

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ABSTRACT

The microstructures of some alkali-silica reactive aggregates used in China have been examined by means of an optical microscope. The aggregates included andesite, tuff, basalt, felsite, diorite-porphyrite, basaltic volcaniclastic rock, chert, siliceous dolostone and limestone, meta-granite, metagranite-porphyry and cataclastic quartzite, belonging to Proterozoic, Palaeozoic or Mesozoic. Dominant reactive phases are chalcedony, cryptocrystalline to microcrystalline quartz and strained quartz.

Introduction

Some concrete structures in China have been affected by alkali-aggregate reactions. These structures include buildings, bridges, railway ties, water-cooling towers, piles and airport pavements[1,2]. Investigations show that reactive siliceous aggregates were involved in some of the structures. Alkali-silica reactive aggregates found recently consist of igneous, sedimentary and metamorphic rocks, as shown in Table 1. Most of them were gravel from Beijing, Pingdingshan, Jinzhou, Suizhong and Changchun. The others were crushed stones from Pindingshan and Yan Mountains localized at Beijing and Jixian. The igneous and metamorphic groups mainly belong to Jurassic, Mesozoic. Age of the sedimentary group ranges from Ordovician to Cambrian, Palaeozoic or Stenian to Statherian, Proterozoic. In this paper, the microstructures of these reactive aggregates are presented.

Microstructures of Reactive Aggregates

The aggregates were cut and ground to form thin sections. Then, the thin sections were submitted to petrographic examination to evaluate the reactive silica minerals and other relative components.

Andesite. This group includes andesite, basaltic andesite and sericitized basaltic andesite. The dominant mineral is feldspar, ranging from several mm to more than 100μm. Among the crystals of feldspar, a few of zones composed of chalcedony and/or microcrystalline quartz are

TABLE 1

Some of the Aggregates Found to be Reactive

Igneous rocks	Sedimentary rocks	Metamorphic rocks
Andesite	Chert	Meta-granite
Tuff	Carbonation chert	Metagranite-porphyry
Basalt	Siliceous dolostone	Cataclastic quartzite
Felsite	Siliceous limestone	
Diorite porphyrite		
Quartz diorite-porphyrite		
Basaltic volcaniclastic rock		

scattered. The amount of reactive silica minerals is about 8–12%. Fig. 1(a), 1(b) and 1(c) show the microstructures of these aggregates.

Tuff. Reactive tuff aggregates are tuff, andesitic tuff and breccia tuff. The tuff is composed of feldspar, andesitic breccia, chalcedony, microcrystalline quartz and biotite. The andesitic one contains sericite, kaolin, feldspar, quartz and microcrystalline quartz. The sericite and kaolin are altered minerals from feldspar. Minerals in the breccia tuff include feldspar, pyroxene, quartz and microcrystalline quartz. The contents of reactive components in the three tuff aggregates are about 15%, 60% and 20%, respectively. The texture of tuff is shown in Fig. 1(d).

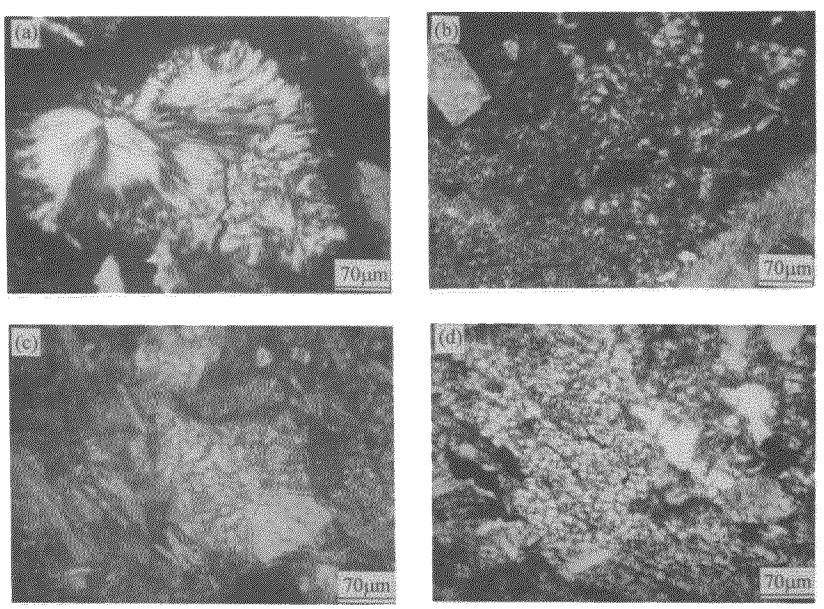

FIG. 1.
The microstructures of reactive andesite and tuff aggregates. (a) andesite; (b) basaltic andesite; (c) sericitized basaltic andesite; (d) tuff.

Basalt. Basalt aggregates consist of feldspar, chalcedony, microcrystalline quartz, quartz and/or glassy material. Their microstructures are demonstrated in Fig. 2(a) and 2(b). Generally, silica minerals may not be involved in basic rocks such as basalt. In question, the chalcedony and quartz might be epigenetic concretion. These secondary minerals account about 6–10% of the aggregates, and the well-crystallized quartz occupies a very small portion.

Felsite. Felsite aggregates comprise feldspar, quartz and microcrystalline to cryptocrystalline quartz. Feldspar in one aggregate shows spherulitic texture. The reactive microcrystalline to cryptocrystalline quartz shown in Fig. 2(c) is in an amount of 30–40%.

Diorite Porphyrite and Quartz Diorite-porphyrite. Diorite porphyrite contains feldspar and altered dark mineral. No siliceous component is petrographically observed. However, X-ray diffraction analysis indicates that there is quartz in the aggregate. The quartz may be cryptocrystalline. Quartz diorite-porphyrite consists of feldspar, secondary sericite and microcrystalline quartz. The content of microcrystalline quartz is about 40%. Fig. 2(d) and 2(e) reveal the microstructures of these two aggregates.

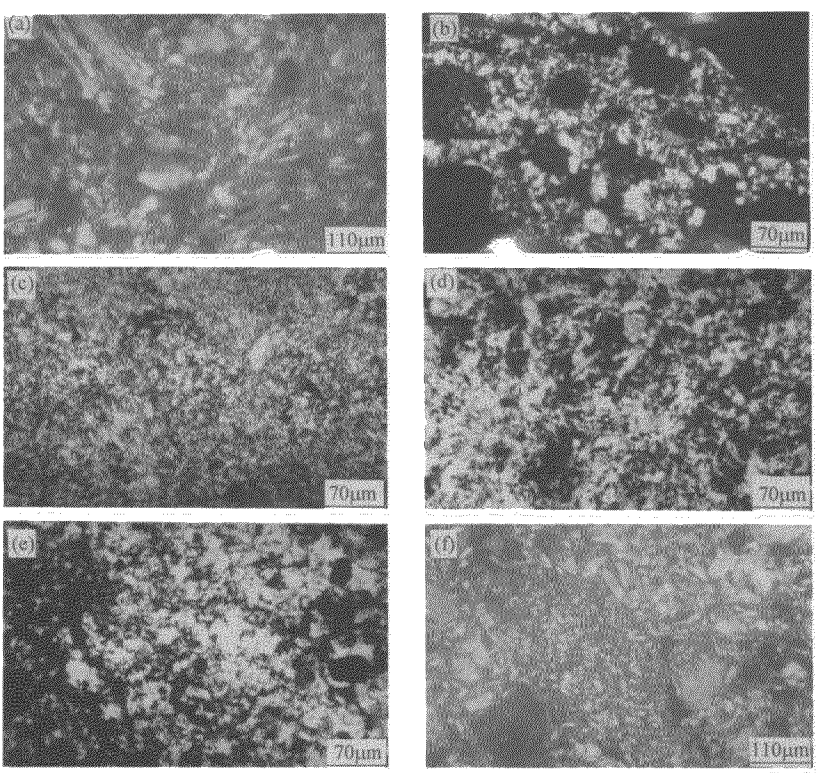

FIG. 2.
The microstructures of reactive igneous aggregates. (a) & (b) basalt; (c) felsite; (d) diorite porphyrite; (e) quartz diorite-porphyrite; (f) vocaniclastic rock.

Basaltic Volcaniclastic Rock. This volcaniclastic aggregate contains feldspar, glass, pyroxene and microcrystalline quartz. The microcrystalline quartz shows strong extinction and its content is about 10%. The microstructure is shown in Fig. 2(f).

Chert and Carbonation Chert. Reactive chert aggregates are composed of well-crystallized quartz, microcrystalline to cryptocrystalline quartz and/or chalcedony. The crystalline quartz is often localized, and its content ranges from 5% to 15%. The microcrystalline to cryptocrystalline quartz is in an amount of 80–90%. Chalcedony is about 0–15%. Fig. 3(a) and 3(b) demonstrate the typical textures of this kind of aggregate.

The majority of the reactive chert group is carbonation chert, which consists of 5–40% dolomite, 0–15% crystalline quartz, 40–80% microcrystalline to cryptocrystalline quartz and 0–15% chalcedony. The fine rhombic dolomite is sometimes distributed in strips. The alkali-dolomite reactivity of these aggregates needs to be further evaluated. Fig. 3(c) and 3(d) illustrate the photographs of the carbonation chert.

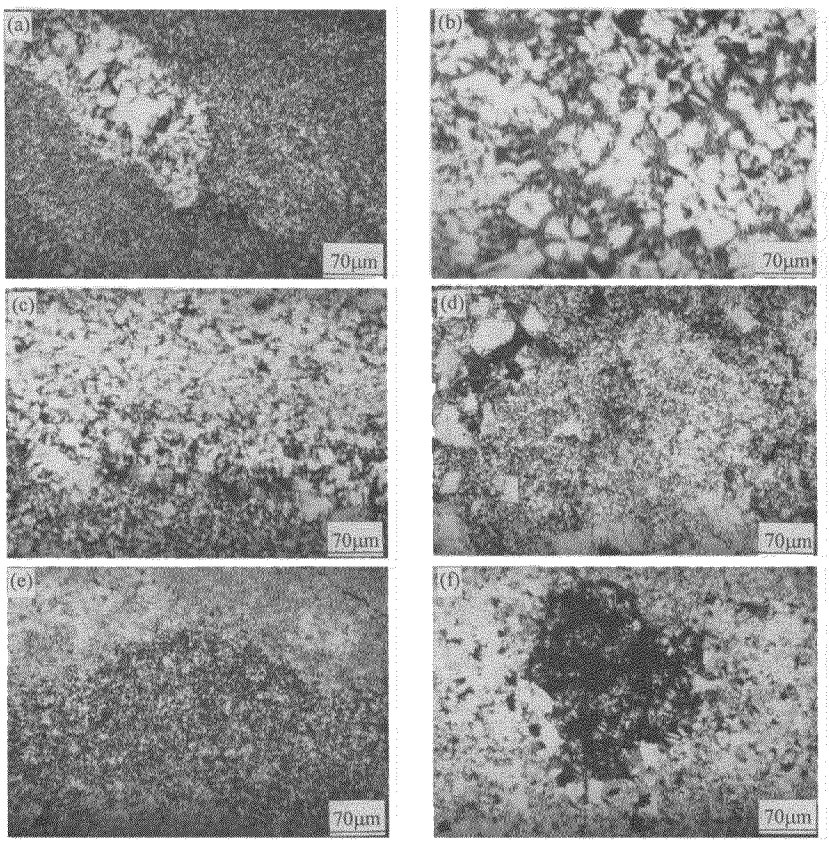

FIG. 3.
The textures of reactive sedimentary rocks. (a) & (b) chert; (c) & (d) carbonation chert; (e) siliceous dolostone; (f) siliceous limestone.

Siliceous Dolostone and Siliceous Limestone. Siliceous dolostone is a dominant reactive aggregate found recently. The aggregates were derived from either rivers or mountains. They contain 50–85% dolomite, 10–30% microcrystalline to cryptocrystalline quartz, 0–10% crystalline quartz and 0–15% chalcedony. The siliceous components are sometimes scattered in patches among the crystals of dolomite. Dolomite in the aggregates is often less than 60–80μm. It is needed to further investigate whether the aggregates are alkali-dolomite reactive. Fig. 3(e) shows typical microstructure of the dolostone aggregates. A few of siliceous limestone aggregates were found being reactive. The reactive minerals are 1–3% chalcedony and about 40% microcrystalline to cryptocrystalline quartz. Typical texture of these aggregates is shown in Fig. 3(f).

Meta-granite and Metagranite-porphyry. The silica mineral in granite is nonreactive well-crystallized quartz. However, if the quartz had suffered a serious stress, rocks with this strained quartz have often been recognized as reactive[3]. The reactive meta-granite comprises feldspar, strained quartz, biotite and chlorite which derived from biotite. Fig. 4(a) reveals texture of the meta-granite.

The metagranite-porphyry aggregates are composed of feldspar, microcrystalline to cryptocrystalline quartz and/or chalcedony. The feldspar mineral occurs as phenocrysts. In some aggregates, it has been seriously altered. Contents of microcrystalline to cryptocrystalline quartz and chalcedony are 65–75% and 0–5%, respectively. The typical microstructures of these aggregates are demonstrated in Fig. 4(b) and 4(c).

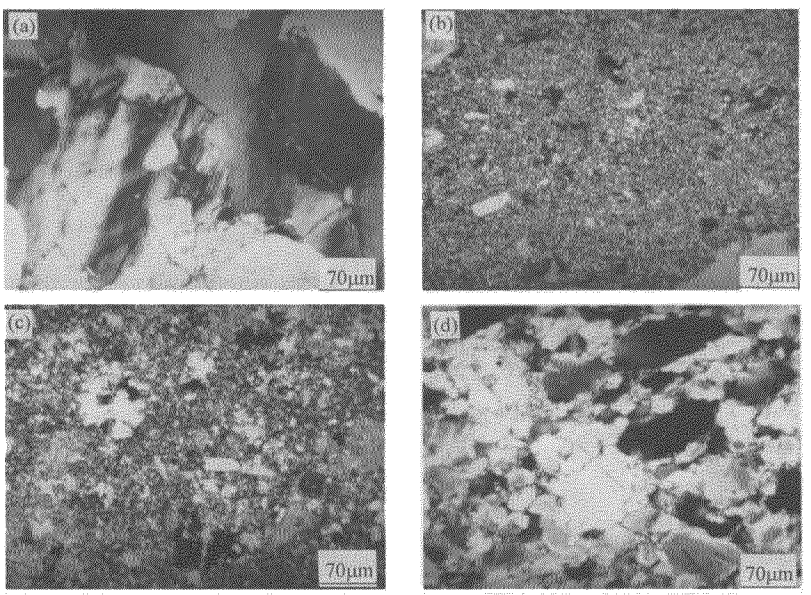

FIG. 4.
Microstructures of reactive metamorphic rocks. (a) meta-granite; (b) & (c) metagranite-porphyry; (d) cataclastic quartzite.

Cataclastic Quartzite. The sole mineral in the cataclastic quartzite is strained quartz as shown in Fig. 4(e). The strained quartz has caused railway ties to be damaged.

Conclusion

Microcrystalline to cryptocrystalline quartz is a dominant reactive mineral included in some alkali-silica reactive aggregates from China. Chalcedony often coexists with microcrystalline to cryptocrystalline quartz. These minerals cause igneous, sedimentary and metamorphic rocks to be reactive. Strained quartz in some metamorphic rocks may be reactive.

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